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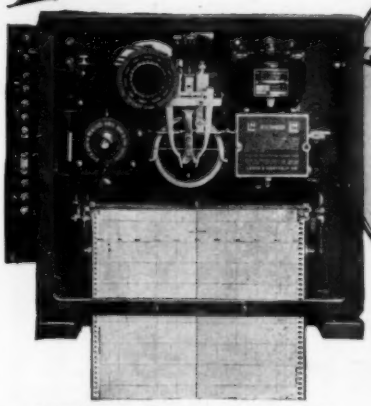

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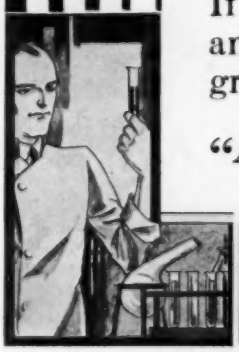

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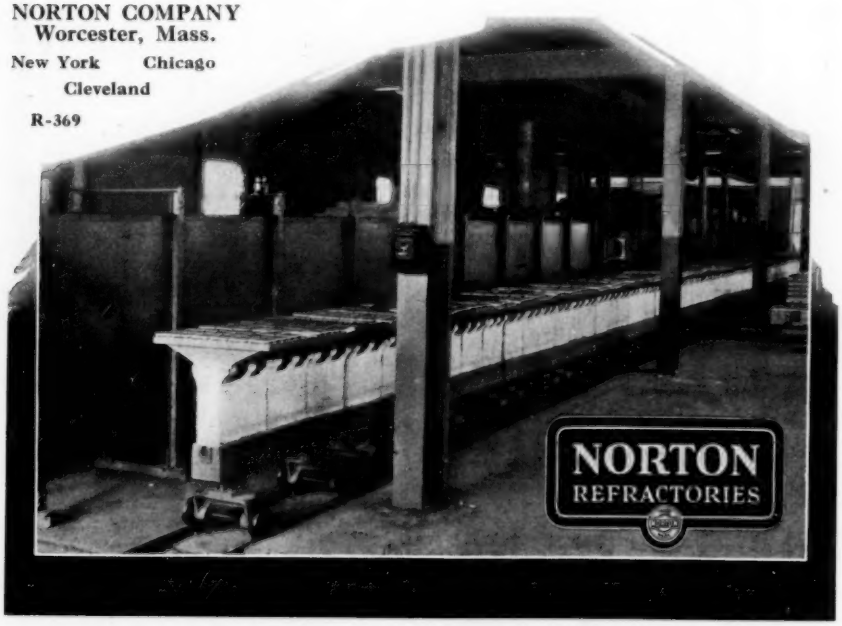

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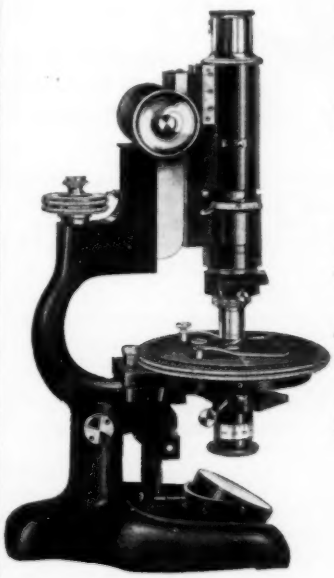

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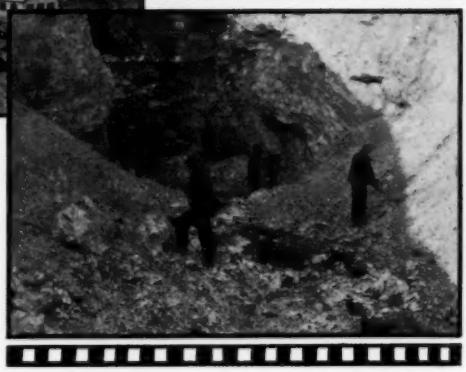

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A STANDARD UNIT OF DIMENSION FOR MASONRY[1]

By Fred T. Heath

ABSTRACT

Construction problems due to lack of coördination in sizes of different masonry materials are pointed out. It is proposed that these difficulties can be overcome by adoption of a standard "unit" of dimension to be used by architects and engineers in dimensioning building plans, and by masonry material manufacturers in determining the size of their products. No definite "unit" of measure is suggested, except that it should approximate one brick length plus one mortar joint, two brick widths plus two joints, or three brick thicknesses plus three joints. The application of the "unit" plan is given for face brick, common brick, paving block, fire brick, cement block, structural clay tile, terra cotta, cut stone, and to masonry openings for windows and doors. Illustrated with 74 photographs of masonry and 2 plates.

Introduction

The object of this paper is to present a constructive plan whereby all building materials which are part of, or are built into masonry walls may be standardized to conform to a common unit of dimension.

Standardization is of the greatest value when all the elements combined into one system are designed in accordance with a common principle. To standardize one element on one basis and another element on some different basis and then endeavor to combine them into a common system results only in confusion and inefficiency. Such partial standardization is oftentimes more harmful than no standardization at all. Established practices are difficult to change, even though they may be out of harmony with other elements of the same system.

Fig. 1.—Brick masonry with terra cotta trim.

The Present Status of Standardization in Masonry

Masonry walls in modern construction are complicated systems in which a large number of elements are combined. In smaller buildings these elements include not only the different kinds of brick, structural tile, cement block, flue lining, stone,

[1]Received August 22, 1929.

and terra cotta; but inserted in the walls are window and door frames and various devices such as coal chutes and cabinets. Walls must also provide chases for pipes and conduits, and flues for ventilating ducts. In the larger skeleton type of building the masonry must be even further coördinated with the dimensions of the steel or reinforced concrete frame.

Independent Standards of Manufacture

At present there is very little coördination between these elements of a wall system. Some of the industries producing wall materials have adopted independent standards for simplicity of manufacture, but there is

FIG. 2. (left). FIG. 3. (right).—Different kinds of masonry materials, flue lining, pipes, conduits, window and door openings, make a complex problem for the builder.

no generally recognized common standard which applies to the dimensions of these products when combined in use.

For instance, the size of common brick and rough face brick is standardized at 8 in. by $2^1/_4$ in. by $3^3/_4$ in. Assuming these brick are laid in $^1/_2$-in. joints, the horizontal wall dimension, center to center of joints, is $8^1/_2$ in. The natural limitation of dimension is a half-brick, and the wall can be constructed in multiples of $4^1/_4$ in. Vertically, the courses are $2^3/_4$ in., center to center. Thus an opening in the masonry is most conveniently constructed only when dimensioned in multiples of $4^1/_4$ in. horizontally and $2^3/_4$ in. vertically. Window or door frames which do not conform to such sizes of openings are inefficient in use in brick masonry walls because of the cutting and fitting required of the mason.

Influence of Standard Glass Size

Most standardization of dimension in the production of metal and lumber window frames has been based on standardized sizes of glass lights rather than any relationship to convenient masonry dimensions. Standardized steel sash for factory buildings are based largely on varying combinations of either 12 in. by 18 in. or 14 in. by 20 in. glass size. The overall dimensions of standardized frames for either metal or lumber sash harmonize with masonry dimensions only by coincidence. Such coincidences are not common, and in practical construction the openings, as indicated on

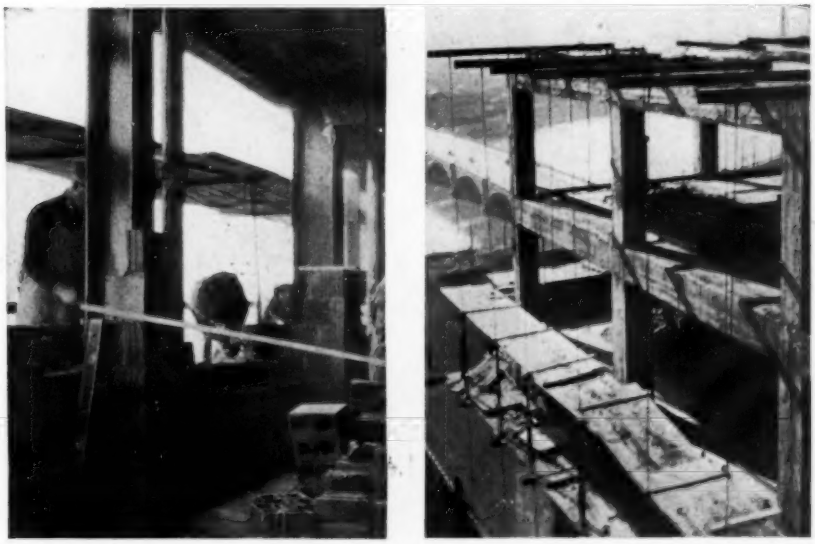


FIG. 4 (left). FIG. 5 (right).—In the larger buildings masonry is combined with steel or reinforced concrete frames.

plans, are juggled and fudged, and brick joints are stretched or tightened, or the brick are cut, all in a wasteful effort to combine these two materials which do not harmonize in dimension.

Glass size is becoming less important in the modern trend of standardization. Top-hung continuous sash for factory buildings, for instance, are now made by most manufacturers in even 3-ft., 4-ft., and 5-ft. heights, and in lengths varying by even 2-ft. increments of measure, and glass is cut to fit as required. The basis for this standardization is simplicity of overall dimensions. The steel window industry is now endeavoring to create an advanced principle of standardization which may be successfully applied to all types of windows. Projected windows designed with overall dimensions in increments of 6 in. are now being produced by five manufac-

turers and double-hung windows on the same basis are being produced by four manufacturers. These dimensions make for simplicity by eliminating the cumbersome fractions which usually occur when glass size governs the sash size. It is pointed out in this paper that the unit of measure which applies to masonry, and which governs the size of masonry openings, is not 6 in., and it is hoped that some common increment of measure can be determined upon which will be satisfactory for both masonry openings and window sizes.

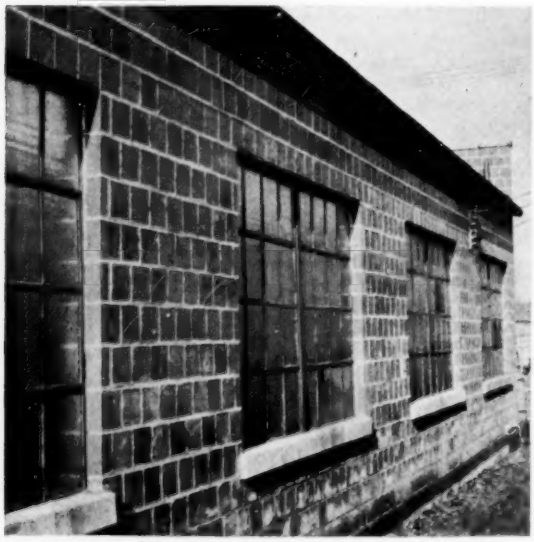


FIG. 6 (upper).—Harmony between sash size and masonry dimensions by coincidence.

FIG. 7 (left). FIG. 8 (right).—Block construction carefully planned to fit around windows.

Box Frames The dimensions of lumber box frames for double-hung windows are a heritage of all frame construction. A standard box frame is $5^1/_4$ in. in depth, which is the correct dimension when inserted in a frame wall with 2-in. by 4-in. studding. The width and height of the frame were immaterial because, in any case, lumber sheathing had to be sawed to fit around the frame. To insert the $5^1/_4$-in. box frame in an 8-in. masonry wall involves expensive complications. The masonry should overlap the box sufficiently to provide for weather protection. Unless the wall is furred on the inside, which increases its thickness to about

10 in., this overlap must be constructed in the space outside of the $5^1/_4$-in. box, which is about $3^1/_4$ in. This is less than the width of a brick, and consequently all the brick at each jamb must be clipped by the mason in order to provide sufficient space for the box. When the wall is of structural tile or concrete units, special jamb shapes are usually provided, at considerable trouble and expense, in order that the traditional lumber dimension of the frame may be accommodated.

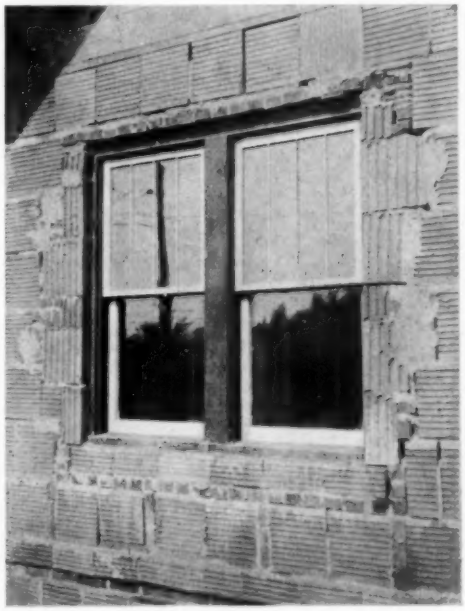


FIG. 9 (left).—A masonry opening which does not conform to brick dimensions.
FIG. 10 (right).—Tile masonry patched around window opening.

Brick and Tile Combined

Coördination to a limited degree has developed between face brick and the larger units, structural tile, concrete and cinder block, which are commonly employed for backing up face brick. The prevailing standard of vertical dimension for back-up units is based on the most common practice of laying $2^1/_4$-in. brick in $^1/_2$-in. bed joints. Units which back up two courses of face brick are 5 in. high, those which back up three courses are $7^3/_4$ in., and the units which match with four courses are $10^1/_2$ in. vertically. These are average dimensions, and under some conditions, special back-up units must be made with slightly larger or smaller dimensions in order to bond properly with brick facing.

Variations in Joint Thickness

The thickness of the joint used in laying face brick will vary, depending upon the desire of the architect or the type of brick. Basically, the type of brick governs, and usage has developed characteristic joint thickness corresponding to each type. The natural beauty of rough texture brick is most apparent when wide joints are used. The refinement of pressed or smooth-face brick calls for the fine drawn lines of narrow joints. Joint thickness is quite appropriately related to the fineness or coarseness of the brick texture, and architects consciously or unconsciously observe this law. Brick might be classified according to joint thickness most commonly used as follows:

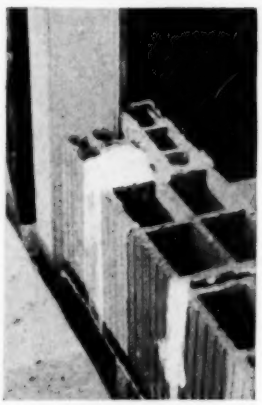


FIG. 11 (upper left). FIG. 12 (upper right).—Face brick clipped to provide sufficient depth for box frame.

FIG. 13 (lower left).—A makeshift for providing recess for box frame in tile masonry.

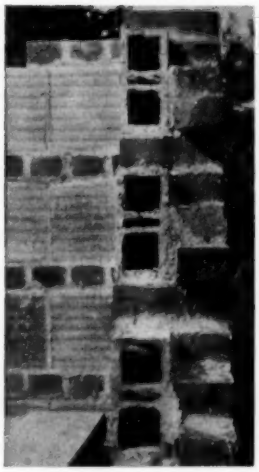
FIG. 14 (lower right).—Special jamb blocks to provide recess for box frame.

TABLE I

No	joint—fire brick
1/8 in.	joint—enameled brick
1/4 in.	joint—pressed brick
3/8 in.	joint—smooth brick
1/2 in.	joint—common brick
5/8 in.	joint—texture brick
3/4 in.	joint—rough brick

Variations in Wall Dimensions

Because individual brick size is standardized, the variation in joint thickness results in corresponding variations in wall dimensions and plays havoc with all efforts to standardize units that must be used in combination with brick. This applies not only to the larger units used to back up brick facing, but is equally important where the face brick are bonded into the



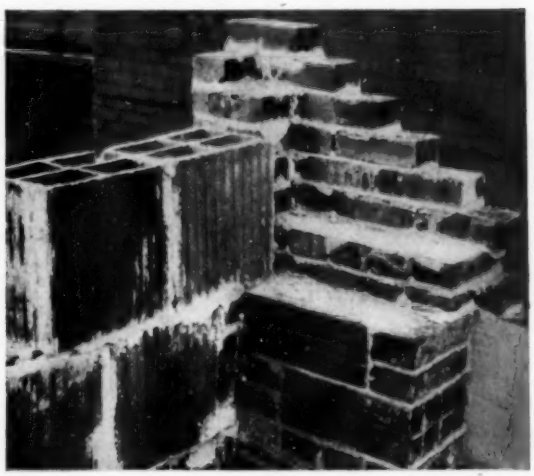
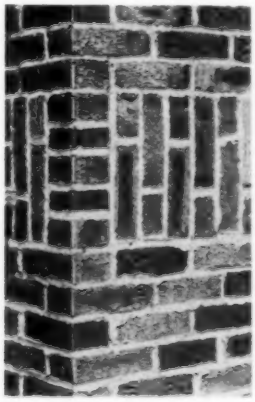


FIG. 15 (left).—A tile unit to match three courses of brick.
FIG. 16 (right).—Several different kinds of masonry units assembled in a wall.

TABLE II

Brick	Thickness		Vertical dimension	
	Brick (in.)	Joint (in.)	1 course (in.)	5 courses (in.)
Enameled	$2^1/_4$	$^1/_8$	$2^3/_8$	$11^7/_8$
Pressed	$2^1/_4$	$^1/_4$	$2^1/_2$	$12^1/_2$
Smooth	$2^1/_4$	$^3/_8$	$2^5/_8$	$13^1/_8$
Common	$2^1/_4$	$^1/_2$	$2^3/_4$	$13^3/_4$
Texture	$2^1/_4$	$^5/_8$	$2^7/_8$	$14^3/_8$
Rough	$2^1/_4$	$^3/_4$	3	15
Maximum variation		$^5/_8$	$^5/_8$	$3^1/_8$



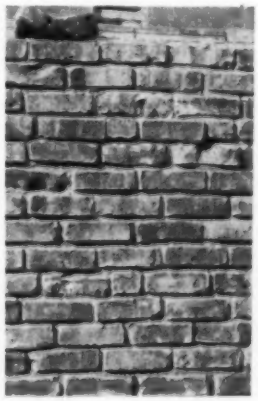
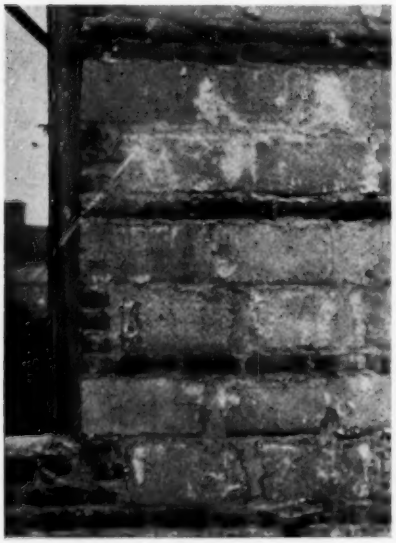


FIG. 17 (left).—Smooth face brick and narrow joints.
FIG. 18 (center). FIG. 19 (right).—Rough-texture face brick and wide joints.

larger units of stone or terra cotta trim. Table II is given to show the actual variations which occur in course heights when standard $2^1/_4$-in. brick of the different types are laid up in the characteristic joint thicknesses.

Thus it can be seen that an apparently minor discrepancy of $^1/_8$ in. in one course height becomes magnified to $^5/_8$ in. in five courses; and the extreme difference of $^5/_8$ in. in a single course height that exists between enameled brickwork and rough-textured brickwork actually becomes $3^1/_8$ in. in five courses. Since every sixth or seventh course is normally the header course, its position may vary by more than 3 in., depending upon the type of brickwork.



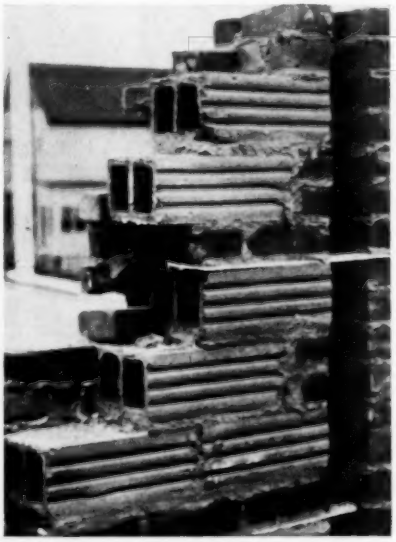


FIG. 20 (left).—Cement block back-up units between face brick header courses.
FIG. 21 (right).—Small tile back-up units between face brick header courses.

The Architect's Problem

These discrepancies in wall dimensions apply in the horizontal plane as well as in the vertical. They are oftentimes the cause of irritating problems in an architect's office. The architect desires that brick facing shall be thoroughly bonded into the back-up masonry. He is even more particular that stone or terra cotta units of exterior trim shall be so dimensioned that they will bond perfectly with brickwork, both horizontally and vertically. He will often select the brick and determine the joint thickness in advance of completing details for ornamental trim, so that the stone or terra cotta units may be accurately dimensioned to harmonize with the brick masonry

dimensions. Not infrequently it happens that the brick selected is not the brick purchased. Perhaps the substitute brick is of an entirely different texture than that originally selected and demands a different size of joint. This can only mean that the architect must redesign the details of the ornamental trim, or the contractor must cut and fit the brick and patch them into the larger units as best he can. In the latter case, the results are neither efficient nor artistic.

Oversize Brick Some brick manufacturers still believe that it is smart merchandising to make their brick oversize and sell them at the same price per thousand as their competitors sell

FIG. 22 (left).—Face brick cut and fitted around stone ashlar.

FIG. 23 (center).—Normal size face brick and oversize common brick cause confusion.

FIG. 24 (right).—Half brick are substituted for full face brick headers in this wall because of the difficulty in bonding two sizes of brick.

standard size brick. The contractor who buys these oversize brick labors under a false impression that he is saving money. In reality, he pays a premium for using such brick when they are combined with standard size brick. Such brick do not fit, and the mason is in a constant turmoil trying to bond one type of brickwork to the other. Very often this results in walls of questionable structural character with half-brick substituted for full headers. Architects seldom have an opportunity of observing these faulty details during the time of construction, and but few contractors have cost accounting systems which enable them to know actual costs of their masonry walls.

A Plan for Standardization

If masonry is ill, as would be concluded from this diagnosis, what is the cure? The remedy lies in organizing the different elements of masonry to conform to a common dimensional system. Brick sizes cannot be considered without joints, and window sizes cannot be independent of the masonry in which they are built. For true standardization, all materials that are part of, or are built into masonry walls, must be dimensioned so as to harmonize with each other.

Measurement of Type The confusion which occurs in the construction of walls might be compared to the problems that existed in the printing trade prior to the adoption of the modern "point" system. Each manufacturer of type had his own sizes. He would create his own styles and put them on any size body he pleased. Type from different sources was not interchangeable, and this was not only inconvenient, but served to retard progress in the printing art.

There are three units of measurement in modern typography, the "point," the "pica-em," or "pica" as it is more commonly called, and the "em." The point and pica are units of linear measure, and the em is the unit of square measure. All type is now made in accordance with these accepted standards of measure and the printing art has advanced intelligently and with efficiency.

Masonry Measurement The "point" system in typography is an arrangement devised by a French printer, Fournier, as early as 1737. It is presumed that Fournier's system came into general use as a survival of the fittest. If precedent is to be a factor in arriving at a similar plan for coördinating the dimensions of materials for wall construction, it is suggested that brick masonry be analyzed as the source of such standard. Almost every masonry structure is composed at least in part of brickwork and consequently brick dimensions influence the dimensions of other masonry materials more than any other single factor.

The nature of brickwork is such that a common unit of measure can be applied to three brick thicknesses plus three joints, two brick widths plus two joints, or to one brick length plus one joint. This relationship is explained in more detail under the headings "Face Brick" and "Common Brick." This plan for standardization is based on this relationship, assuming that it can be made exact, and that the unit of wall dimension can become a standard measure in terms of inches or feet.

Linear, Surface, and Volume Measure Printing is confined to a plane surface so the "point" system standardizes only linear and square measure. Masonry is built in three dimensions, so the standard should include volume, as well as linear and square measure. The measure of dimension is identical for the length,

width, and height of masonry walls, and it is suggested that the term "unit" would be appropriate. Unit area would logically be one unit square and unit volume would be a cube of one unit in each dimension. Terms for these measures of area and volume are not essential until the linear "unit" is determined in value.

Use of Standard This plan of standardization would eliminate the architect's problem. He would no longer be required to select his masonry materials and type of window prior to completion and dimensioning of his plans. The architect could design his masonry in "units" with assurance that standard masonry materials,

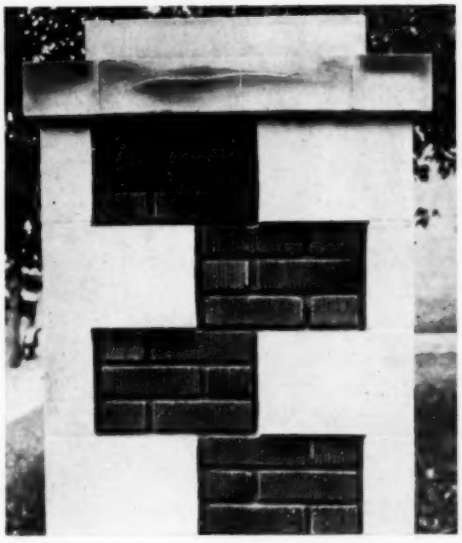


FIG. 25 (left). FIG. 26 (right).—Brickwork influences the dimensions of other masonry materials.

windows, doors, etc., would fit into his design in an efficient manner. To give greater latitude in design, the unit could be divided into half-units in the horizontal plane or into third-units in the vertical direction without a great sacrifice in efficiency. For instance, a whole unit may give a sufficient variation in window heights, but it may be desirable to use a half-unit as the increment of measure for window widths. Standard masonry would conform satisfactorily to half-unit dimensions in the horizontal direction.

Unit Must Be Constant It has been stated in the introduction that the object of this paper is to present a constructive plan whereby masonry walls may be standardized on a common unit of dimension. It would be presumptuous to suggest that such a unit should

be 8 inches, 9 inches, 20 centimeters, or any other constant value. The unit must be some constant, however, and the success of the plan depends upon its universal recognition and use. Architects and engineers, as well as building material manufacturers, will have opinions to offer on this subject, and it is hoped that the discussion may point toward some common unit which can be generally accepted as a standard.

Face Brick

The dimensions for face brick at present recommended are:

Rough-texture face brick—8 by $2^1/_4$ by $3^3/_4$ in.
Smooth-texture face brick—8 by $2^1/_4$ by $3^7/_8$ in.

It is commonly understood that twice the width of a brick plus one mortar joint is the equivalent of the length of a brick. Rough-texture face brick are usually laid in $^1/_2$-in. joints, whereas smooth-texture face brick are laid in $^1/_4$-in. joints. This explains the difference of $^1/_8$ in. between the widths of the rough- and the smooth-texture face brick. In the case of the rough brick, two headers plus one $^1/_2$-in. joint equal 8 in., as illustrated in Part (*c*) of Plate II. Again with the $3\ ^7/_8$-in. smooth brick, two headers plus one $^1/_4$-in. joint equal the length, 8 in. This is shown in Part (*d*) of Plate II. The smaller joint is thus compensated for by wider brick, and the desired bond relationship of headers and stretchers is maintained.

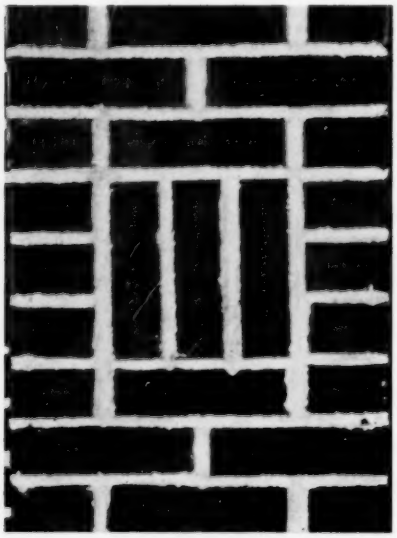


FIG. 27.—"One soldier equals three courses."

Compensation for Joint Variation

This discrepancy of $^1/_8$ in. provided for in the present recommended size standards is a recognition of the principle of dimensioning set forth in this paper. In the interests of better and more efficient construction, this compensation in brick dimensions for varying joint thickness should apply to all three dimensions of the brick. If smooth-texture face brick were the same width as rough-texture face brick and yet laid in $^1/_4$-in. joints as compared with $^1/_2$-in. joints for the rough-texture brick, then the rule "two headers equal one stretcher" could not work out for both. To arrive at true standardization, the variables

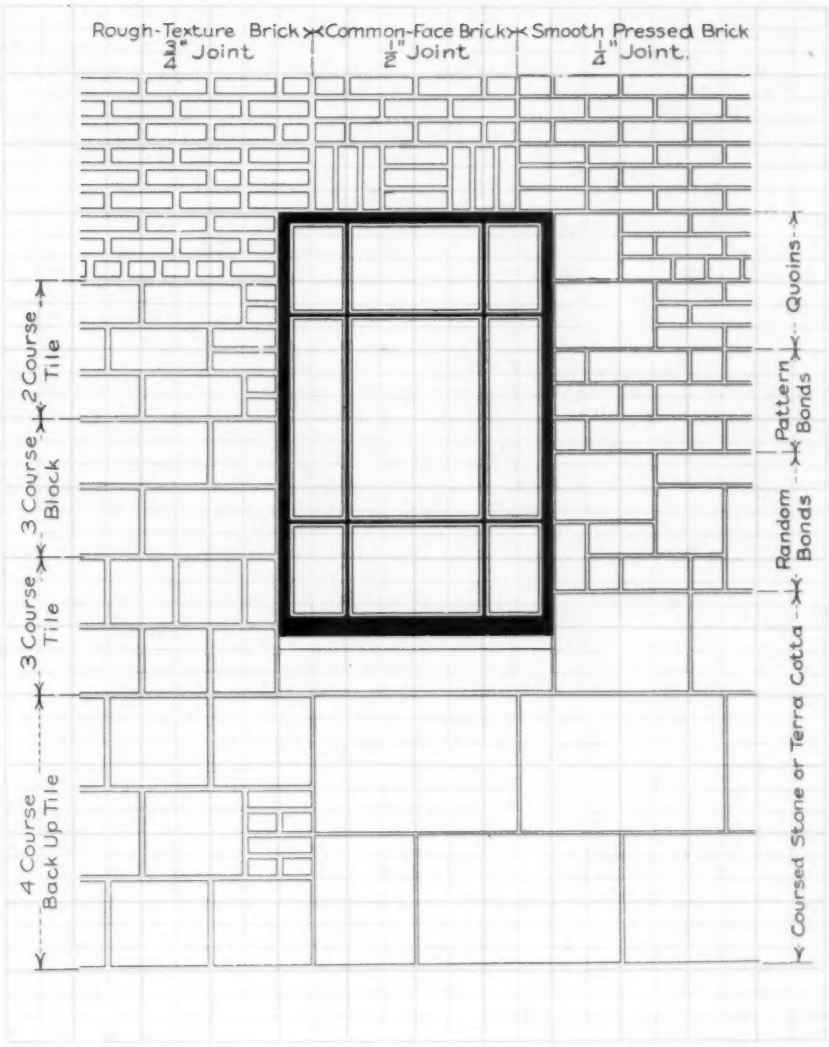
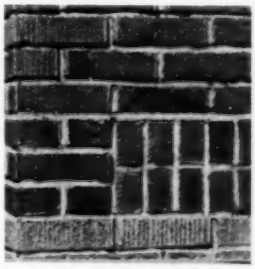
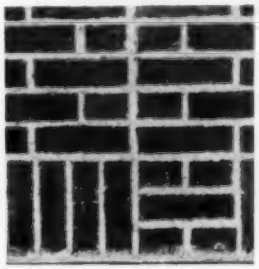


PLATE I.—A graphical representation of the universal application of a standard "unit" of dimension for masonry.

must be eliminated. In the case of masonry, where varying joint thicknesses are established and desirable, it seems essential that the brick dimensions should be made to compensate so that in each of the three dimensions the brick size plus the joint thickness will give a constant unit of measure.

Brick Proportions The usual facebrick bonds and patterns are predicated on the principle that the width of a brick is essentially one-half its length and that its thickness is one-third its length. These proportions would be exact for individual brick, if brick were perfect and laid without joints. The practical brick, however, must be laid in mortar; consequently, the size of the brick must be decreased in each dimension by the thickness of the mortar joint. There are a number of rules for bonding in brickwork. The one most generally understood is that





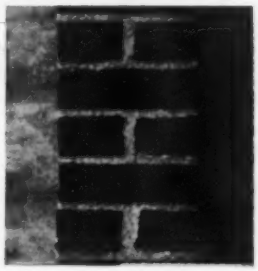


FIG. 28 (left).—"Unit" in the horizontal direction is one stretcher, two headers, three rowlocks, or three soldiers (as in Fig. 29).

FIG. 29 (center).—"Unit" in the vertical direction is one soldier, two rowlock courses (as in Fig. 28) or three normal courses.

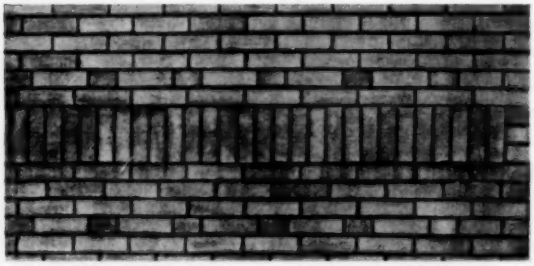
FIG. 30 (right).—A wall of "unit" thickness less one mortar joint.

"two headers equal one stretcher." Other rules that apply are that "three rowlocks equal one stretcher" or "one soldier equals three courses." If brick were dimensioned strictly in accordance with the principle shown in Part (*b*) of Plate II, then these bonding relationships between thickness and length could be as accurately worked out as the relationships between headers and stretchers work out at present. One "unit" represents the distance along stretcher courses, from center to center of joints. This same "unit" applies to the distance along header courses, from center to center of alternate joints. With properly dimensioned brick, the "unit" will also apply to the distance from center to center of every third rowlock or soldier joint. In the vertical direction on a wall surface, the "unit" would apply to the distance from center to center of every third bed joint in normal brick courses, every other joint in rowlock courses, or every joint in soldier courses. The same "unit" governs the wall thickness.

That which is commonly considered an 8-in. wall, is, in reality, a wall of "unit" thickness less one mortar joint.

Rule for Brick Size The "unit" should be determined from the viewpoint of convenience in design and dimensioning of architectural plans, and by common consent among masonry material producers. Joint thickness is now fairly well established by usage at about $^1/_2$ in. for common brick and most face brick, and from $^1/_4$ in. to $^3/_8$ in. for smooth-texture face brick. With these two factors determined, a manufacturer of brick need but apply the following simple rule to determine the correct size for his brick:

Length = unit − one joint
Width = one-half unit − one joint
Thickness = one-third unit − one joint



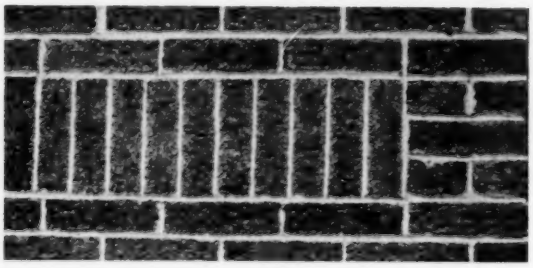
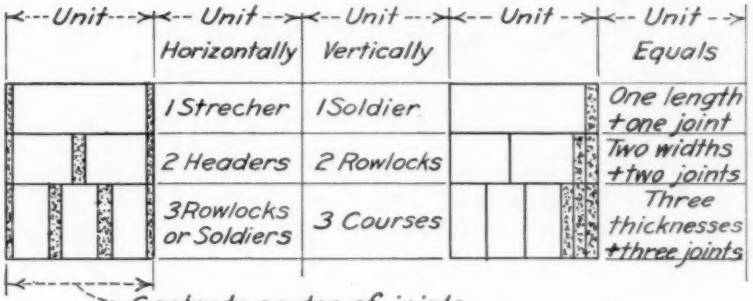


FIG. 31 (upper).—A soldier course in brickwork.
FIG. 32 (lower).—An extra soldier in three stretchers of length.

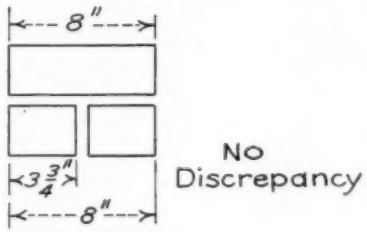
If a manufacturer desires to make a very rough-texture brick adapted for laying in $^5/_8$-in. or even $^3/_4$-in. joints, the brick would be smaller than those for laying in normal joints. On the other hand, should a manufacturer desire to make smooth-pressed brick which should be laid up in thin $^1/_4$-in. or $^1/_8$-in. joints, they would be made correspondingly larger. Fire brick, which are laid in the thinnest possible joints, would approach the theoretically perfect brick that requires no joints.

Discrepancies of Present Size To make critical analysis of the standard dimensions for face brick, as adopted, involves pointing out discrepancies which seem to exist due to lack of understanding of the rule which governs brick size. For example, the recommended standard size for rough-texture face brick is the same as that for common brick, 8 in. by $3^3/_4$ in. by $2^1/_4$ in. This size is presumably based upon a joint thickness of $^1/_2$ in., which establishes the "unit" along stretcher courses at $8^1/_2$ in. Applying the rule, the size is found to be 8 in. by $3^3/_4$ in. by $2^1/_3$ in. Apparently, the theoretical thickness of $2^1/_3$ in. has been

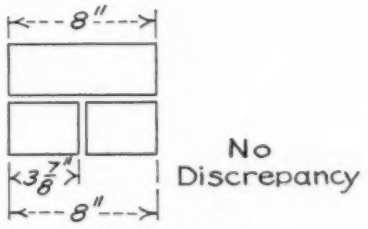


Part (a) Part (b)

A RULE PROPOSED FOR BRICK SIZE

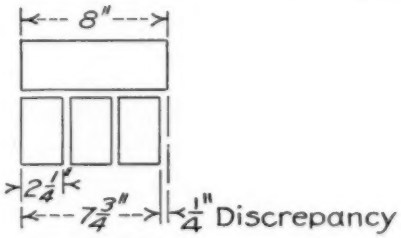


Part (c)

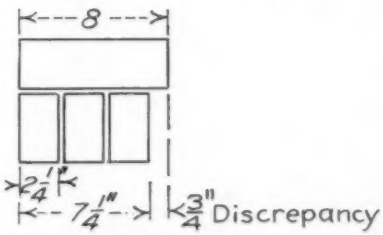


Part (d)

Relationship between Width and Length



Part (e)



Part (f)

Relationship between Thickness and Length

ANALYSIS OF PRESENT BRICK SIZES

PLATE II.—A graphical study of brick proportions.

modified to $2^1/_4$ in. The difference, $^1/_{12}$ in., seems insignificant, but in three courses this amounts to $^1/_4$ in., a discrepancy which must necessarily be compensated for in the joint thickness, if the bonds are to be worked out accurately. See Part (*e*) of Plate II.

Figure 31 shows a result frequently observed in soldier courses. Instead of exactly three soldiers matching with each stretcher, it may be noted that there is one extra soldier in a distance corresponding to five stretchers. It may also be observed that extra thick bed joints were required in laying the three half-brick which terminate the soldier courses at the corner. Figure

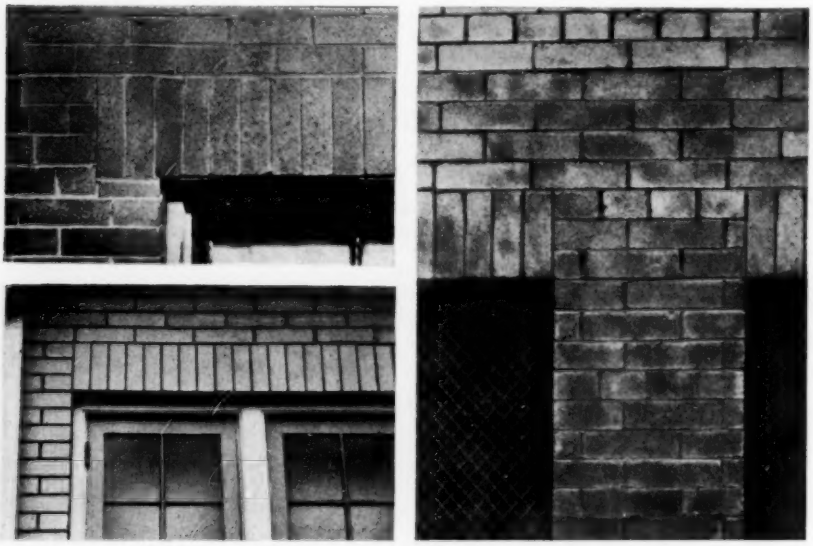


FIG. 33 (upper).—Full brick used as soldiers are too long for three courses of brick laid in narrow joints.

FIG. 34 (lower).—Brick are clipped to make soldiers corresponding to three courses.

FIG. 35 (right).—Clipped soldiers—also masonry openings which do not coincide with vertical joints of brickwork.

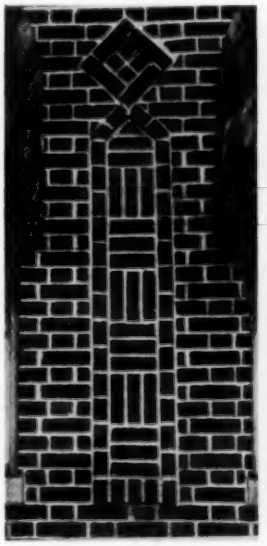
32 is another similar illustration of brick proportioned slightly too thin for their length. In this case the soldier brick are also laid with thin joints between them, so that one extra soldier occurs in three units of length.

More serious discrepancies occur in the case of smooth-texture face brick. It has been pointed out that the width is adjusted to compensate for the thinner joint. This is illustrated in Part (*d*) of Plate II. The discrepancy occurs in the relationship between the thickness and length. Assuming a joint thickness of $^1/_4$ in., the "unit" along stretcher courses is $8^1/_4$ in. Following the rule, the computed size is 8 in. by $3^7/_8$ in. by $2^1/_2$ in.

The discrepancy in thickness is now $^1/_4$ in. in each course, or $^3/_4$ in. in the "unit" distance. See Part (*f*) of Plate II.

Construction Problems

This inaccuracy in the relationship between the length and thickness causes the mason considerable difficulty, particularly when standard size brick are being laid in tight joints. Figure 33 illustrates one way in which he endeavors to solve the problem. The soldiers are obviously too tall for the army they have joined. Another way in which the mason solves this problem is shown in Fig. 34. In this case he has clipped the ends of each brick that



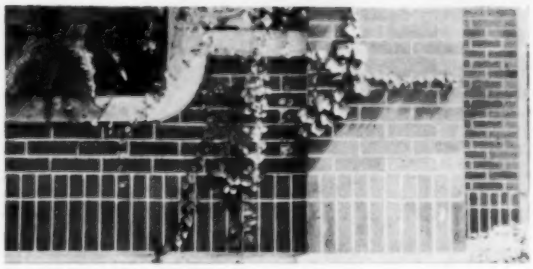


FIG. 36 (left).—Ornamental pattern in brickwork.

FIG. 37 (upper).—Soldiers used continuously to avoid matching three courses of brick.

FIG. 38 (lower).—Brick pattern worked out to avoid conflict in length-width relationship.

was put in the soldier course so that these brick are actually 7 in. long and thus they match out even with three courses in height.

Figure 35 is another example of the use of clipped brick in the soldier course. Proof that the soldier brick have been clipped lies in the fact that the length of one stretcher is about $^3/_4$ in. more than three soldiers, whereas the length of the soldier brick corresponds exactly with three courses of the brickwork. This same reasoning applies to Fig. 34. Figure 35 illustrates further the excessive amount of brick cutting required of the mason due to the fact that the masonry openings do not happen to correspond with the vertical brick joints. The laying of face brick becomes very costly where so much cutting of brick is required.

It has been observed that soldier courses are seldom used in brickwork that has thin joints. On the other hand, where wide joints are used, soldier courses and brick patterns are found in almost every building. One method of using soldier courses in thin joint brickwork is shown in Fig. 37. This avoids clipping the soldiers to match three courses of brick. Figure 38 also shows an interesting decorative treatment where end-set brick are not required to match with side-set brick. Figures 39 and 40 illustrate still other expedients to which masons have resorted to overcome the deficiency in proportion which results when brick of the present size is laid in narrow joints.

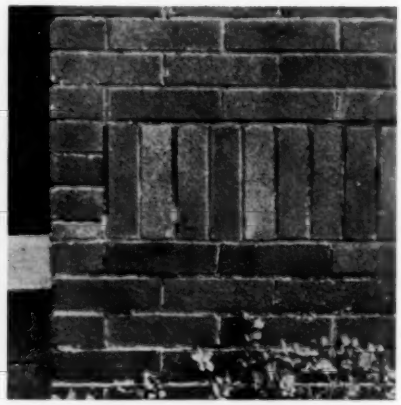


FIG. 39 (left).—Four brick trimmed down in thickness to match with soldiers.
FIG. 40 (right).—Three brick and a piece of brick to match with soldier course.

Average Dimensions These expensive complications would not exist if brick were dimensioned in accordance with the principle that has been outlined. It must be understood that all references to brick or tile sizes apply to average dimensions. The manufacturing process is far from being generally perfected to a point where firing conditions are uniform throughout a kiln, and consequently the underfired ware is larger, and the overfired ware smaller than average size. These variations, however, are not of sufficient magnitude but that they may be compensated for in joint sizes, giving wall dimensions essentially in accordance with this proposed standard.

Common Brick

The most frequent companion of common brick masonry is face brick masonry. Face brick are often backed up with common brick. It is desirable that these two types of masonry be well bonded to each other.

This bond occurs on the interior of the wall so that the exact nature of the bond is difficult to determine, except by observation during construction.

Common Brick Size The present recommended standard size for common brick is the same as that for rough-texture face brick, 8 in. by $2^1/_4$ in. by $3^3/_4$ in. Common brick are normally laid in $^1/_2$-in. joints. When such a wall is faced with standard size rough-texture face brick, that are also laid in $^1/_2$-in. joints, the courses work out even and a good masonry bond is practical. If it happens that the face brick are laid in thin joints, such as the $^1/_4$-in. joints desired for smooth-texture face brick, then the courses do not work out even and a masonry bond is difficult.

FIG. 41 (left).—A face brick front joining a common brick side wall.

FIG. 42 (center).—13 courses of common brick level up with 14 courses of pressed face brick.

FIG. 43 (right).—18 courses of enameled face brick backed up with 17 courses of common brick.

Face Brick Fronts In buildings constructed with face brick fronts and common brick side and rear walls, it is interesting to observe the walls where the two types of masonry join. Sometimes the courses are the same for both the face and the common brickwork, in which case the two types of masonry may be bonded to each other every course. When the course heights in one type of brickwork are not the same as in the other, then a vertical joint separates the two kinds of masonry, or they are bonded by blocking as shown in Figs. 44, 45, and 46.

Rolok-Bak Walls In normal common brickwork there are few occasions where the relationship of width to length becomes of importance, as it does for constructing soldier courses and pattern bonds in face brick masonry. Hollow walls of brick, however, particularly "rolok-bak" walls, are based on a very definite relationship between width and thickness. In some cases, two courses edgewise must level up to three courses flatwise, or more frequently, four courses of brick on edge and six courses of brick laid flat must bring the wall level on top, ready for the header course.

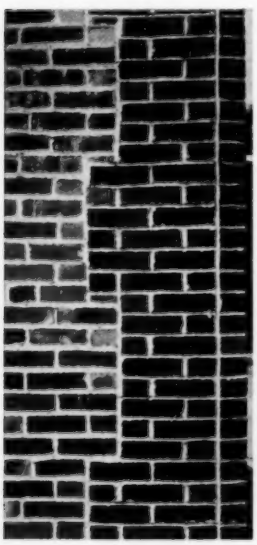


FIG. 44 (left).—A face brick front blocked into a common brick side wall.
FIG. 45 (center).—An example of unsightly bonding between face and common brick.
FIG. 46 (right).—An addition to existing building with a problem in matching old brickwork.

Rule for Size With this relationship to observe in the construction of "rolok-bak" walls, it is important that the brick used be dimensioned according to the same rule as already given for face brick:

Length = unit − one joint
Width = one-half unit − one joint
Thickness = one-third unit − one joint

As in the case of face brick, the "unit" represents the distance along stretcher courses, from center to center of joints, or along header courses from center to center of alternate joints, or along rowlock courses from center to center of every third joint.

Since most common brick are laid in normal $^1/_2$-in. joints, common brick will all be made essentially of one size. It is only face brick that need be manufactured in varying sizes to compensate for varying joint thicknesses used in laying the different types. This plan gives reasonable assurance that course heights, lengths, and widths will work out the same for both types of masonry. Under these conditions, walls with any type of bond desired can be constructed with maximum efficiency.

Paving Block Paving block seconds are often used in masonry construction. Such block are employed with bonding relationships that imply their width and thickness to be essentially one-half their length. Where paving block are used in conjunction with other masonry units, it would be desirable to have their size based on the same unit dimension as applies to these other materials. The rule for determining the size of paving brick would therefore be:

Length = unit − one joint
Width = one-half unit − one joint
Thickness = one-half unit − one joint

This would make two courses of paving block the equivalent of three courses of normal brickwork.

FIG. 47 (left).—Paving block facing trimmed with stone.
FIG. 48 (right).—Three courses of face brick front bonded into two courses of paving block side walls.

Fire Brick

The Refractories Manufacturers Association adopted size standards for clay fire brick shapes in 1913. The straight brick is 9 in. by $4^1/_2$ in. by $2^1/_2$ in. and the auxiliary shapes are based on this same 9-in. length and $4^1/_2$-in. width, or $2^1/_2$-in. thickness. Many shapes are required such as wedges, keys, necks, skews, arches, and circle brick. A standard of some kind was essential to coördinate the use of the different shapes, but the standard adopted seems to be independent of any other standard for size prevailing for common or face brick.

Accurate Size Required Fire brick are used to build refractory linings in furnaces, kilns, flues, or other masonry subjected to high temperature or direct flame action. Fire brick are made of expensive refractory clays and are manufactured with great precision and care. This is essential in order that the brick may be accurate in size, with plane faces and true edges. The brick are usually dipped in a fireclay slip and set in place with the thinnest possible joint.

It is sometimes desirable that the firebrick lining be bonded into the remainder of the furnace wall with header courses the same as face brick are bonded to the masonry back-up. This requires that the remainder of the furnace wall be laid up in course heights that will permit of such bonding. This is difficult to do with the present conflicting standards and frequently the remainder of the furnace wall is constructed of firebrick seconds, or special size brick made to correspond with the fire brick.

Dimensioning Rule Under the proposed uniform standard of dimension for all masonry units, fire brick would be designed according to the rule as given for other types of brick. Fire brick are laid with practically no measurable joint, and their size would approximate the standard wall dimensions. Since these wall dimensions apply to all kinds and types of brick, the fire brick would then harmonize perfectly with the remainder of the wall and any manner of bonding desired could be efficiently carried out.

Insulating Brick Insulating brick should also conform to the dimensioning rule so that they will harmonize with the fire brick masonry of the furnace lining and the ordinary masonry on the outside of the furnace walls.

Block and Tile

The desire for speed and efficiency in modern construction has led to the development of sizes of masonry blocks larger than brick. These large sizes are generally made with voids or cells to decrease their weight and facilitate handling. These cells also add to the insulating value of the masonry.

One class of these blocks is known as structural clay tile and another is cement block. There are other materials used for forming these blocks, such as gypsum and wood fibers, but the ceramic and cement blocks are most commonly used.

Use of Blocks This class of material has been used principally in basement walls, garages, farm and factory buildings, and the like, where architectural appearance is not a prime requisite. A few manufacturers are developing the production of this type of material with special textures, glazes, or other surface treatments that make these blocks

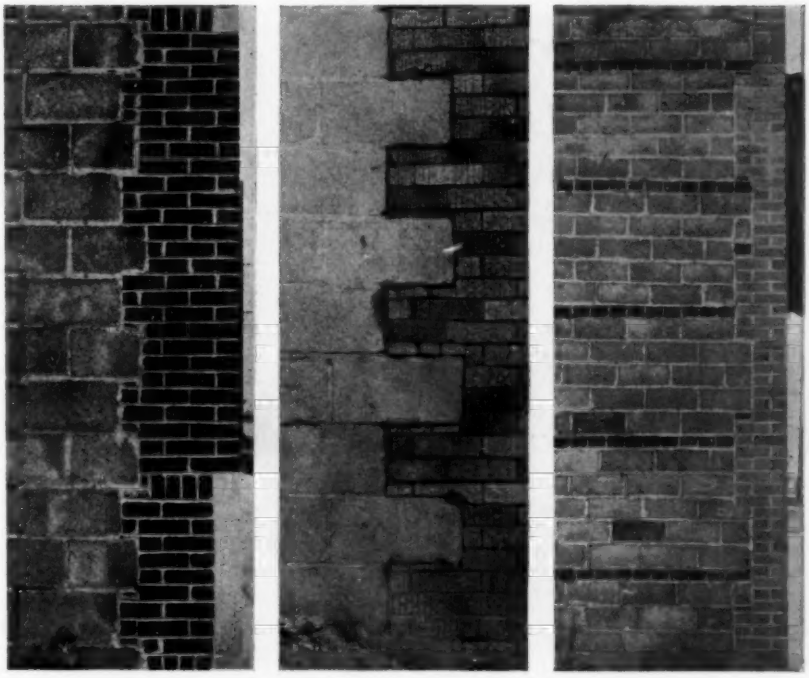


FIG. 49 (left). FIG. 50 (center). FIG. 51 (right.)—Examples of lack of coincidence in course levels of face brick fronts and cement block side walls.

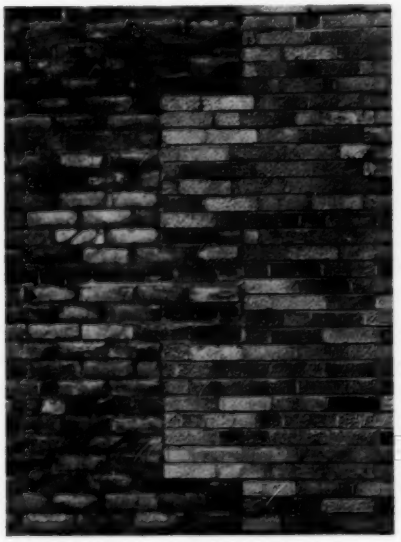
very suitable for exposed masonry. They are being used for both exterior and interior walls and some very artistic results are obtained. In the better residences, however, apartments, office buildings, schools, and similar construction, the masonry materials used on the exterior are usually face brick, stone, or terra cotta. Blocks and tile are used for efficiency but as backing for the facing materials, particularly face brick.

Complex Complications As has been pointed out, the result of these combinations of materials is an extremely complex system. It has also been shown that the size relationship between these materials is not exact. The complications which result from this lack of coördination tend to offset the efficiency which might be expected from the use of the larger and lighter units of block and tile.

Block Dimensions Based on Brick Size Because of the fact that these block and tile are used in combination with brick masonry, the unit dimensions of brickwork have had a decided influence on the dimensions of the larger blocks. For instance, the heights of the blocks almost invariably correspond to two,

FIG. 52 (left).—Exterior of wall at juncture of face brick front with common brick side wall.

FIG. 53 (right).—Interior of same wall shown in Fig. 52 showing faulty construction due to difference in brick course levels.



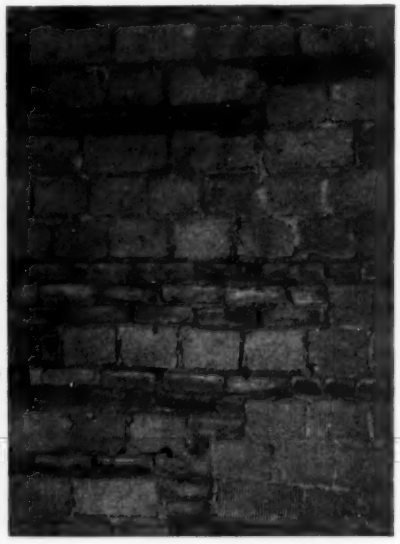


FIG. 54 (left).—Exterior face brick wall blocked into common brick side wall.

FIG. 55 (right).—Block back-up masonry at line of juncture shown in Fig. 54.

three, or four brick courses. The widths of the blocks correspond to one, two, or three brick widths; and their lengths coincide with one, one and one-half, or two brick lengths.

The relationships are necessarily approximate because brick masonry dimensions are variable, depending upon size of joint. Variation of vertical dimensions is shown in Table II, and similar variations occur in brick masonry widths and lengths.

FIG. 56 (left). FIG. 57 (right).—Confusion, inefficiency, and hazardous construction are the result of oversize common brick.

Special Tile Sizes Coincidence in the vertical dimension is essential where blocks are used with brick facing in order that the two types of masonry may be bonded together. A number of structural clay tile manufacturers make a block designed to correspond with four courses of face brick. Normally, the block is dimensioned $10^1/_2$ in. vertically. This size plus $^1/_2$-in. joint gives 11 in., which corresponds to four courses of standard $2^1/_4$-in. brick laid in $^1/_2$-in. joints. Very frequently, however, these block must be made as specials with vertical dimensions $9^1/_2$ in., 10 in., 11 in., or $11^1/_2$ in., as may be required, to take care of the

cases where the face brick are being laid in joints thinner or thicker than the normal $^1/_2$ in. Such specials are expensive to produce, and construction is occasionally held up for lack of them.

Face Brick Fronts There are a great many buildings, such as store buildings, speculative apartments, and houses, in which the use of face brick is confined to the fronts of the buildings. The side and rear walls may be common brick, block, or tile. In a sense, this is false construction, but nevertheless it exists. As has been mentioned under "Common Brick," this affords an opportunity to inspect the two types of masonry and to visualize the degree of coördination, if any.

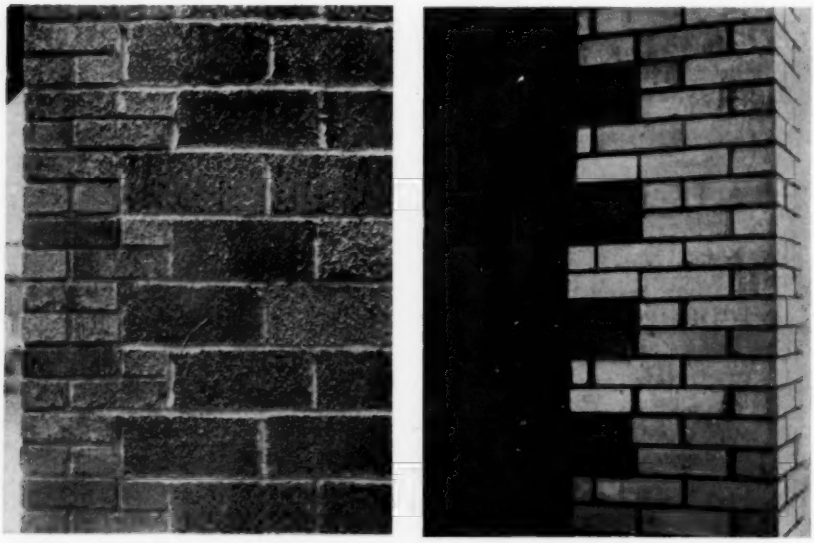


FIG. 58 (left).—12-in. tile bonded with a brick increment of bonding.
FIG. 59 (right).—12-in. tile bonded with 6-in. increment of bonding necessitates cutting and fitting at juncture with brickwork.

If there is lack of coördination between the course heights of the face brick front and common brick side walls, and both of these materials are used only for facing, and are backed up with block or tile, then a three-way complication arises which can only result in defective masonry. The accompanying illustrations are included as evidence that such complications are not hypothetical. In fact, they are frequent occurrences in localities where oversize common brick are still marketed. In these localities, determination of the size of brick and tile becomes a real problem. If the block or tile are small enough to bond properly with standard size face

brick, they are then too small to bond with oversize common brick. If they are made large enough to bond with oversize common brick, then they are too large to bond with standard size face brick. Confusion, inefficiency, and hazardous construction are the result.

Bonding Increments of Brick and Tile A complication arises between 12-in. lengths of structural tile and brick, in the bond lengthwise of the wall. This is illustrated in Figs. 58 and 59. A 12-in. tile is essentially one and one-half "units," and in normal construction the overlapping bond is 6 in. or three-fourths of a "unit." The bonding overlap in brickwork is approximately 4-in. or one-half "unit." Thus in joining these two types of masonry, a discrepancy occurs amounting to one-fourth unit in the increment of bonding. This requires cutting of either the brick or the tile in order to complete the wall. This conflict can be, and usually is, avoided by bonding the tile with a 4-in. or half-unit overlap, rather than the normal three-fourths unit bonding increment.

Tile are frequently used with a half-unit bonding increment even when the tile masonry is not combined with brickwork. Unless this is done, many difficulties arise at corners, or wherever the length of one wall merges into the thickness of another. The increment in width of tile dimensions and also of bond is invariably one-half unit. Unless the same increment of bond applies lengthwise, there must be some means of compensation. This usually takes the form of special shapes, special lengths, or cutting and fitting at the corners, pilasters, or wherever one wall bonds into another. Figure 16 is an example of this complication.

Rule for Size of Blocks To fit into the scheme of standardized masonry, as herein proposed, blocks and tile would be dimensioned according to the following rule, in which x represents any whole number such as 1, 2, 3, 4, etc.:

Lengths = x half-units − one joint
Widths = x half-units − one joint
Heights = x third-units − one joint

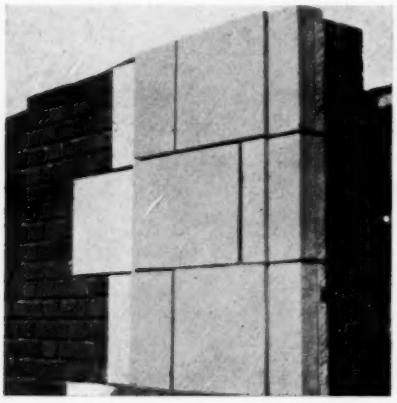
Terra Cotta

A standard unit of dimension would be of great benefit to the terra cotta industry. Standard terra cotta units could be designed which would, in all cases, harmonize with the other units which complete the masonry. This would simplify many problems which now exist where terra cotta is used for trim, as around doors and windows, corners, belt courses, cornices, and the like.

Job Lay-Outs At present very little terra cotta is standardized in size. The usual procedure is to design all terra cotta units for each particular job. The architect's plans are turned over to the designing

department of the terra cotta manufacturer, and this department lays out the job, details all joints and assigns a number to each separate piece for the entire job. These numbers are marked on each piece as it is produced, and the pieces must be sorted out and set on the job strictly in accordance with schedules provided by the designing department.

Special Molds On any one job, there are many shapes identical with others and which are made on the same mold. This is particularly true of terra cotta ashlar, which may be designed almost entirely in one size of unit, or which may be combinations of several standardized sizes to form pattern or random bonds. The very derivation of the term "molding" implies units produced from the same mold or pattern. Thus each terra cotta job has groups of like pieces and at least one mold



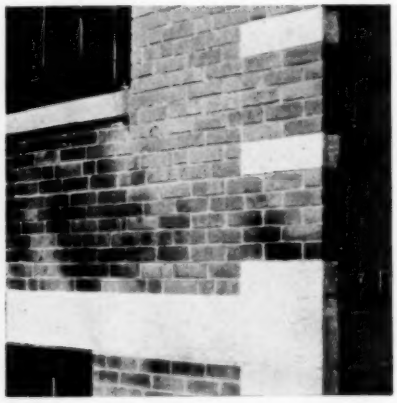


FIG. 60 (left).—Terra cotta trim bonded into face brick and back-up with common brick.

FIG. 61 (right).—Terra cotta belt course and inserts made in brick dimensions.

for each group. The number of molds required for any one job will depend upon the type of architecture, ornamentation, and skill of the designing department. When the job is completed, the molds are discarded. Only in rare instances are molds designed for one job found suitable for some other job.

Standard Molds With "units" of wall dimension standardized, as proposed, this unit could govern the method of detailing joints in the designing departments of the terra cotta manufacturer. This would be particularly appropriate if the architect observed the standard unit of measure in determining the overall dimensions of the walls, and the size and position of openings.

Under such a scheme, the number of different terra cotta units would be

materially decreased. Odd-dimensioned units would seldom occur. Molds for ashlars, belt courses, moldings, quoins, and other plain pieces would not have to be discarded. They could be used on numerous jobs, and the pieces made from them could be carried in stock for rush shipments. These standard plain pieces could be efficiently manufactured at times when production orders were slack.

Mechanical Methods Made Possible

Improved and more efficient methods of manufacture would be made possible by a reduction in the number of shapes. Molds could be standardized so that mechanical pressing methods would be practical to replace a large part of the present expensive hand labor methods. Plain ashlars and molding could be readily extruded by an auger machine through hollow-ware dies and cut to lengths varying in unit multiples. Such blocks would be uniform, light, strong, and efficiently produced. The savings effected in producing the plain pieces could be invested in high-class skilled workmen and artisans to further develop the artistic qualities of the ornamental portions of the terra cotta which express the architect's vision of beauty and individuality. By decreasing variation in size, it is possible to increase variation in color and texture, which are effective mediums for the expression of individuality and distinction.

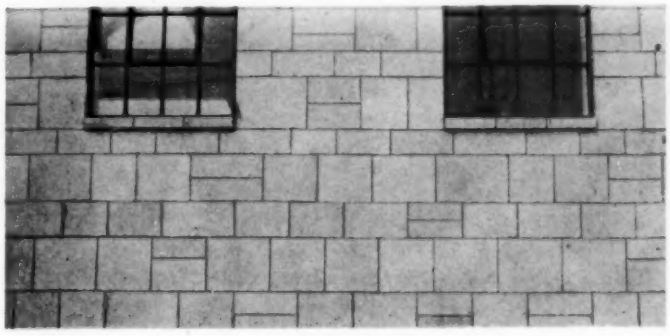


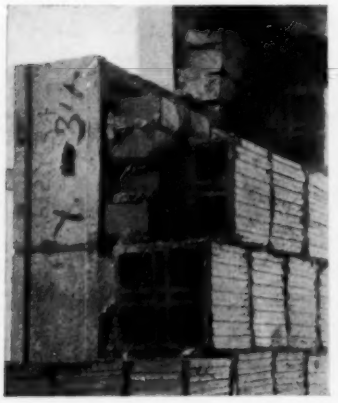
FIG. 62.—Terra cotta random ashlar designed with a dimensioning principle.

Dimensioning Principle Now Used

A principle of dimensioning, similar to this unit plan, is used in a limited way in nearly every case of terra cotta ashlar design. For instance, in Fig. 62 the distances from center to center of joints vertically are 3 in., 6 in., $7\frac{1}{2}$ in., 9 in., 12 in., 15 in., and 18 in. Horizontally, the center to center of joint distances range from 12 in. to 27 in., varying in

even increments of 3 in. In each case the block size is decreased to allow for the joint thickness; that is, the block for a 12-in. by 18-in. wall area is made approximately $11^{3}/_{4}$ in. by $17^{3}/_{4}$ in.

Many of the construction difficulties that occur in combining block or tile masonry with brickwork become even more complicated problems in combining terra cotta with either brickwork or tile masonry or both. Block and tile are related to average brickwork dimensions, but in the case of an all terra cotta facing, there is seldom any exact relationship to facilitate the bonding of the facing to the remainder of the wall. The setting of terra cotta could be made much less expensive if the terra cotta blocks were dimensioned to harmonize with the masonry dimensions of the entire wall. It is suggested that the dimensioning rule given for block and tile might be observed for designing terra cotta or cut stone without imposing excessive limitations of design.



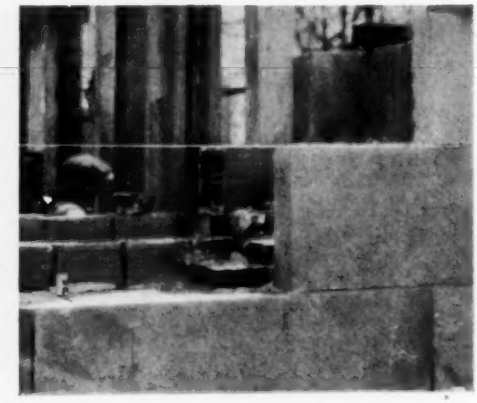


FIG. 63 (left).—Terra cotta back filled with brick and brick bonded into tile masonry.
FIG. 64 (right).—A combination of brick and tile masonry faced with cut stone.

Cut Stone

A great many of the advantages of a standard unit of masonry dimension that have been pointed out in relation to terra cotta, apply also to stone-facing units. Stone cut in accordance with this plan would fit perfectly with other masonry materials. For instance, if the stone were used for trim on a face brick wall, the face brick would bond into the stone units without cutting and fitting. Or, if the entire wall is faced with cut stone, there would be assurance that the courses would level up with those of the back-up masonry. This insures a good masonry bond for the thicker bond stones, and again eliminates wasteful cutting and fitting.

Standardized Production Cut stone is much like terra cotta in that each job must be laid out on a drafting board and each stone detailed. The stones must then be made according to these details and assembled on the job according to the predetermined plan. By utilizing a common basis of measure, however, in detailing stone work, the ashlars, sills, lintels, quoins, and other plain stones become to some degree standardized. These common sizes could be cut and dressed for stock, utilizing the off-peak production periods and avoiding unemployment. In any industry production by spurts proves expensive, and any means to obtain more uniform and continuous production is welcomed.

FIG. 65 (left). FIG. 66 (center). FIG. 67 (right).—Examples of brick masonry trimmed with cut stone.

Distinction Retained The individuality, which is always sought for by architects, is in no respect sacrificed by observing the plan proposed. Large stones can be used for large buildings and small stones for small buildings, so that scale will be preserved. Stones may be laid up in narrow courses or wide courses, and the stone faces may range from square to long and narrow rectangles, all according to the architect's desires and objective in his design. Perhaps an elevation, as laid out at present, would give a certain number of stones whose faces would measure 17 in. by 23 in. Under the scheme of coördinated measure, the limitation of

dimension would be one-half or one-third unit. If the unit were 8 in., the stone would be changed to occupy a space 16 in. by 24 in.

The actual stone size would be somewhat less than 16 in. by 24 in., depending upon the thickness of the mortar joints used in laying the stonework. If $^1/_4$-in. joints were used, as is customary in stone setting, the face of this stone would measure $15^3/_4$ in. by $23^3/_4$ in. The unit-of-measure scheme must necessarily apply to "center to center of joint" dimensions.

FIG. 68 (left).—Cut stone front bonded as well as possible into common brick walls.

FIG. 69 (center).—Three kinds of masonry and three independent schemes of dimension.

FIG. 70 (right).—Tile masonry backing stone and conforming to complicated dimensions.

Pattern and Random Bonds

This principle of dimensioning would be particularly applicable to pattern and random bonds in cut stone. These bonds call for some underlying scheme of dimensioning to coördinate the blocks as they are assembled.

Masonry Openings

If the different kinds of masonry materials appear to be ill at ease with each other, it is little wonder that any existing standards of brick or other masonry dimension have had so little influence on the size of window and door frames. Apparently only two major influences have been felt, 2-in. increments of measure in glass size, and more recently a desire to simplify overall dimensions. At no time have masonry dimensions been an important factor.

Masonry Must Fit Windows

Windows and doors are not adjustable in size, so in all cases the masonry must provide for the desired opening dimensions. This sometimes imposes a considerable amount of cutting, fitting, and patching to the detriment of the

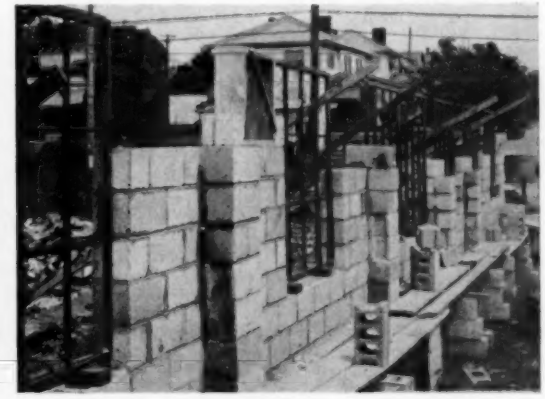


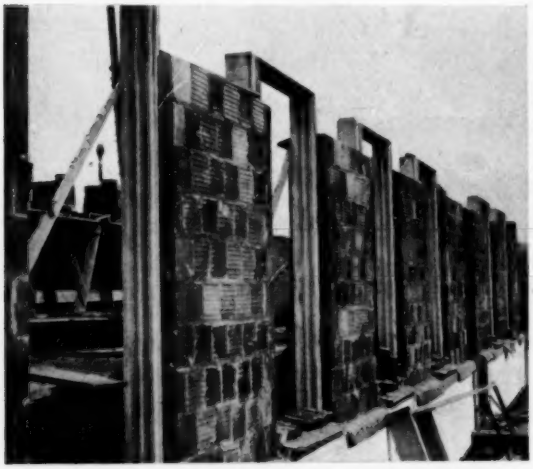
FIG. 71 (left).—Brick cut so the masonry conforms to windows.
FIG. 72 (right).—Cement block garage planned to fit the windows.

masonry. Brick can be cut so that the brickwork will conform to the dimensions of the frames and sash, but the problem is more complex for the larger units of block or tile. To avoid cutting, the openings must be so spaced that the piers or walls between them will require only whole or half blocks. If the designer of the building has not observed the block size in dimensioning his plans, then the dimensions must necessarily be changed to accomplish this. If these irregular dimensions must be strictly adhered to, then the blocks must be cut or special lengths used.

Coördination of Size

With the unit plan of dimensioning, masonry openings would vary in size in definite increments of measure that might be readily observed by manufacturers of windows and doors. Not only could there be coördination of overall dimensions of width and height, but also in thickness or depth. Box frames would fit per-

fectly in their three dimensions, and the present costly patching of the masonry would be eliminated.



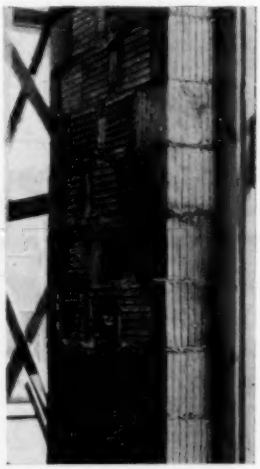


FIG. 73 (left).—Positions of the windows shifted slightly to avoid cutting of masonry units.

FIG. 74 (right).—An odd-dimensioned masonry pier between windows.

Conclusion

This proposed plan has many advantages inherent to any organization of effort. Primarily it results in efficiency, not only in the production of the materials involved, but essentially so in their use. It would be a major step in the simplification of masonry construction.

Better Masonry A better quality of masonry would result. To eliminate cutting and fitting, patching, and excessively thick joints, can only mean stronger, drier, and more fire-resistant walls.

Standardizing Other Building Materials Since the masonry walls surround the building, the unit of measure of the walls more or less automatically standardizes the dimensions of such materials as joists, beams, girders, interior columns; in fact, all the major structural elements of the building. There could also be standard lengths of pipe and conduit, ventilating ducts, mail chutes, wood or metal trim, and other appurtenances of building construction.

Broad Permanent Standard Standards which are not general in their application are sometimes difficult to enforce. Standards broad in their scope, and which affect a number of industries become quite permanent when once introduced. The standard proposed has the advantage of affecting a large number of industries and professions.

Perfects Architectural Design It is seldom that standard or stock materials are conducive to good architectural design. This plan does insure perfection of design. A recognized principle of architectural design is to proportion masses with simple ratios and to have similarity in the proportions of different-sized areas. This plan makes it possible to carry these true proportions of areas down to the details of the design such as masonry jointing and window glass size.

Simplified Planning Architects and engineers will make a substantial saving in the preparation and dimensioning of plans. Manufacturers will save the greater part of the cost of special engineering drawings, which are usually submitted for approval. Standard drawings dimensioned for checking will be all that are necessary with a standard unit of dimension.

Efficiency It is conceivable and quite probable that there are architects with highly individualized tendencies who will react unfavorably to any suggestion of a standard in masonry. If the prevailing custom is to lay smooth brick in thin joints and rough brick in thick joints they will reverse the order, specifying thick joints for smooth brick and thin joints for rough-textured brick. It is believed, however, that such practices, although occasionally noted at present, will fall into an increasing minority with the adoption of a rule of dimensioning as simple as herein proposed. If put into effect by coöperative action, the plan should promote greatly increased efficiency in the building industry.

PROGRESS REPORT ON INVESTIGATION OF FIRECLAY BRICK AND THE CLAYS USED IN THEIR PREPARATION[1]

By R. A. Heindl and W. L. Pendergast

ABSTRACT

This is a progress report of an extensive study of fire clays and fireclay brick. It includes the results of a preliminary study of clays representative of those used in the manufacture of refractories throughout the United States. Chemical analyses and a summary of physical tests are given of both fire clays and the brick manufactured from them. The thermal expansion behavior of the fire clays fired at 1400 °C and those of the fire brick "as received" from the manufacturer and also after firing at 1400 °C, 1500 °C, and 1600 °C were studied and the materials classified into groups having characteristic thermal expansions. The moduli of elasticity and rupture were determined at 20 °C, 550 °C, and 1000 °C. The resistance of the brick to spalling in a water-quenching test is expressed in an empirical relation correlating the elasticity, strength, coefficient of expansion, and percentage of grog used in compounding the brick batches. Data are presented on individual bricks made by the same manufacturer showing probable reasons for great differences in the number of quenchings required to cause spalling in the water-dip test.

I. Introduction

An extensive study was undertaken in the summer of 1926 of the representative clays and grogs used in the manufacture of clay refractories in the principal producing districts of the United States. The program outlined for this investigation includes the following studies of fire clays and fireclay refractories:

(1) Chemical and petrographic analyses.
(2) Determination of their elastic deformation under load at room temperature, 550°C, and 1000°C.
(3) Observation of linear thermal dilatation.
(4) Investigation of the effect of temperature on certain physical properties.
(5) The effect on the finished refractory of grog fired at different temperatures, the amount and grading, and what the effect may be, whether crushed or ground.
(6) Reactions, at high temperatures, of the clay refractories with typical slags.

It is also planned to make a comparison of the properties of the commercially prepared fire brick and fire brick made in the laboratory, using commercial batches. A study of the properties of blended clays, similar to that itemized above, is also contemplated.

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[1] Publication approved by the Director of the Bureau of Standards of the U. S. Department of Commerce. Received June 7, 1929.

A preliminary report of this investigation has appeared as *Technologic Paper*, No. 4, American Refractories Institute.

Published simultaneously in the Bureau of Standards, *Journal of Research*.

The laboratory testing of fireclay refractories to determine those properties which are believed to be directly related to the life of a refractory in service, as emphasized in recent publications by Geller,[2] and Phelps,[3] has led to the conclusion that more data on properties other than those already generally investigated were essential. Producers of refractories are aware that the method of manufacture employed greatly affects the physical properties of the finished product. They do not know, except in a general way, either the qualities of the individual clays, raw or fired, or their relation to the properties of the final product in which they may be used. There can be little doubt that the physical properties of a refractory are affected, not only by the texture and composition of the clays and grog entering into its manufacture, but also by the relation of the qualities of the blended clays, and grog and clays, to each other. Unless the properties of the individual clays entering into a blend are known, no conception is possible as to whether the finished product is in a highly strained state or whether during heating and cooling internal stresses are set up which may cause rupture between individual particles having different properties and eventually cause failure of the refractory.

The purpose of this work is, therefore, to obtain data which will lead to a better understanding of the interdependence of raw materials and manufacturing methods. It would seem evident that a knowledge of the important characteristics of the fire clays, how they are altered when subjected to different degrees of heat, the effect when blended together of one clay on another and how these characteristics are affected by the physical structure of the manufactured product should prove of great value in assisting the producer of fireclay refractories to choose those clays most desirable for a particular product or a product used for a particular purpose.

II. General Information on Materials

The materials were furnished by twelve manufacturers of refractories. They include 17 different brands of fire brick; several hundred pounds each of 26 clays used in the brick, prepared grog, and green batch. With one exception, detailed information of the composition of the batch was given, and also the method of manufacture and the temperature of firing of the finished product. The clays are as follows: 7 flint, 4 semiflint, 12 plastic, and 3 miscellaneous.[4] In addition, 3 samples of quartz and sand are included.

[2] "Testing of Fireclay Brick with Special Reference to Their Use in Coal-Fired Boiler Settings," Bur. Stand., *Tech. Paper*, No. 279.

[3] "Properties of Refractories and Their Relation to Conditions in Service," *A.S.M.E. Trans.*, Jan.–April, 1928.

[4] The miscellaneous clays cannot be properly classified with clays of the other three types.

Each brand of fireclay brick when received was assigned a key letter so that the 17 brands included in this study are identified with letters A to R, inclusive but with the letter "O" omitted. The clays and other materials from which the bricks are manufactured are identified as far as possible with the same key letter as the brick in which they are used. Since most bricks are made from two or more clays the materials are further identified by a number following the letter, *e.g.*, "A-1" and "A-2" are used in the manufacture of fireclay brick brand "A."

Since the nature of the clays and the method of manufacture of fireclay brick have a decided influence on the properties and consequently the life of the refractory on the various conditions of service, it was considered advisable to obtain as much general information as possible on the materials included in this study. In succeeding tables will be found listed the various types of clays or other materials entering into the manufacture of the 17 brands of fire brick, the location from which they are obtained, and the methods employed in the manufacture of the various brands of brick.

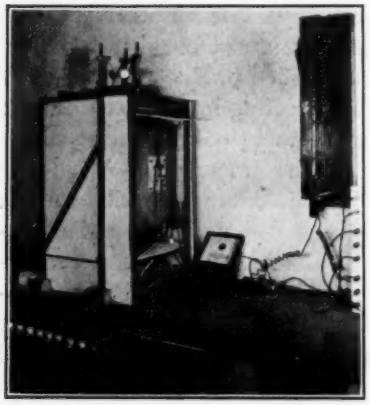

FIG. 1.—Furnace and apparatus used in the determination of linear thermal expansions.

III. Methods of Testing

(1) Thermal Expansion The linear thermal expansions of the fire clays were determined with the interferometer.[5] This method was used because a sufficiently representative specimen of fire clay of the small size required could readily be prepared for test purposes. The thermal expansions of the fire brick were determined by an indirect method[6] with the apparatus shown in Fig. 1, on specimens approximately 1 by 1 by 6 inches cut from the brick. Because most fireclay brick are composed of one or more fire clays and various percentages of coarse and fine grogs, it is essential to make observations on a large specimen so that the data obtained may be representative of the whole brick.

Thermal expansion determinations[7] from 20 to 1000°C were made on specimens cut from the brick, "as received," after reheating for five hours at 1400°C, 1500°C, and again after heating three hours at 1600°C.

[5] Described in Bur. Stand., *Sci. Paper*, No. 485.

[6] For a description of the apparatus and method used see *Jour. Amer. Ceram. Soc.*, 9 [9], 555–74 (1926).

[7] Room temperature was approximately 20°C during these experiments.

(2) Modulus of Elasticity, Transverse Strength, Maximum Elongation, and Plastic Flow

The apparatus used, in observing deflections of the specimens under various loads and determining transverse strength (modulus of rupture) is shown in Fig. 2, and a detailed description of it and the method for determining the load-deflection curves are given in the Third Progress Report of the Sagger Investigation.[8] The modulus of elasticity and modulus of rupture were determined at several temperatures, the former from the load deflection curve and the latter using the load which broke the specimen. The values of the maximum elongation were computed by dividing the modulus of rupture by the modulus of elasticity.

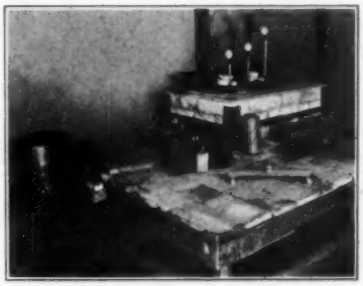

FIG. 2.—Apparatus used in determining elastic and plastic flow properties of fireclay brick.

The plastic flow at 1000°C of the various brands of fire brick was determined with the same apparatus as was used to determine the elasticity and breaking strength. The plastic flow of the material under any particular stress increment was considered as the "set" or difference between the deflection caused by the load and the recovery of the material on removal of this load.

A detailed description of the method for determining this property is given in the Fourth Progress Report of the Sagger Investigation.[9]

(3) Thermal Spalling Test

The spalling test was made on five bricks which had been reheated at 1400°C for five hours. The general procedure followed is described in "United States Government Master Specification for Fireclay Brick."[10] The test requires one end of the brick to be heated in the door of a suitable furnace maintained at 850°C. At hourly intervals the hot end of the brick is immersed in running water for three minutes to a depth of four inches. After removing and allowing the specimen to steam in the air for five minutes, the cycle is repeated until the entire end of the brick has completely spalled.

A modified form of this spalling test was used to permit of some comparison of results obtained on bricks tested under different conditions. Samples of the brick "as received" were placed in the door of the laboratory kiln so that one end of each brick received the prescribed reheating for five hours at 1400°C, the other end being exposed to room temperature. The

[8] *Jour. Amer. Ceram. Soc.*, **10** [7], 524–34 (1927).
[9] *Ibid.*, **10** [12], 995–1004 (1927).
[10] Bur. Stand., *Circ.*, No. 299.

test was otherwise conducted in the same manner as that described above except that the reheated end of the brick was immersed two instead of four inches.

(4) Softening Point (P.C.E.) The softening point (P.C.E.) test was carried out according to the method approved by the Bureau and known as the A.S.T.M. standard method, serial designation, C24–20.

(5) Chemical Analysis In making the chemical analyses of the fire clays and fireclay brick the procedure followed was, in general, the method described by Lundell and Hoffman.[11]

(6) Supplementary Studies The absorption of the brick was determined "as received" from the manufacturer and also after refiring at 1400°C for five hours. The samples were dried and weighed, boiled for four hours, and left in the water approximately 18 hours, and re-weighed. The absorption, expressed in per cent, was computed by dividing the weight of water absorbed by the weight of the dry test piece.

The various sizes of the grog in the green batch materials furnished by the several manufacturers were determined on a 500-gram sample previously dried for approximately 24 hours at 110°C. After drying, sieve analysis of the sample was made by the wet method.

Petrographic examinations were made on three flint and three semiflint unfired clays.

IV. Results

(1) Petrographic Examinations[12] Petrographic examination of the several flint and semiflint clays included in the investigation gave the following information:

Sample D-1 (Missouri semiflint; "North Missouri").

(*a*) A clay mineral (kaolinite or leverrierite) is abundant but in exceedingly fine plates.

(*b*) Isotropic (amorphous, colloidal aggregates?) material is present, but it is difficult to estimate quantity, probably less than in C-1.

(*c*) Quartz is probably somewhat coarser grained than in C-1 and is very abundant, probably more than 40%.

(*d*) Minor constituents are present in small quantities. No rutile (TiO_2), siderite ($FeCO_3$), or rhodochrosite ($MnCO_3$) was observed.

Sample Q-1 (Missouri flint clay).

(*a*) Consists largely of a clay mineral in fine grains and amorphous, isotropic material.

(*b*) No carbonates such as siderite or rhodochrosite are present.

[11] "Analysis of Bauxite and of Refractories of High Alumina Content," Bur. Stand., *Jour. Research*, Research Paper, No. 5.

[12] Petrographic examinations made by H. Insley.

(*c*) Quartz is present only in small amounts, probably less than 5%.
(*d*) A few grains of a mineral of very high index were observed, possibly a titanium compound.

Sample B-1 (Pennsylvania semiflint).

(*a*) A clay mineral (kaolinite or leverrierite) in minute plates is abundant.
(*b*) Isotropic (amorphous, colloidal aggregates?) material is somewhat less abundant than (*a*).
(*c*) Siderite or rhodochrosite is present in small amount, probably less than 5%.
(*d*) Fairly coarse-grained quartz is present in small amounts (less than 10%).
(*e*) There are other minor constituents such as Fe_2O_3, TiO_2, etc.

Sample C-1 (Pennsylvania flint).

(*a*) A clay mineral (kaolinite or leverrierite) in minute plates is slightly less abundant than in B-1.
(*b*) Isotropic (amorphous, colloidal aggregates?) material, index about 1.57, often containing particles of (*a*), is slightly more abundant than in B-1.
(*c*) Siderite or rhodochrosite is more abundant than in B-1, but there is probably less than 10% present.
(*d*) Quartz is fairly fine-grained and in somewhat larger amounts than in B-1.
(*e*) A small amount (less than 2%) of what appears to be rutile is present.

Sample I-1 (Kentucky semiflint).

(*a*) A clay mineral which occurs in small plates is abundant.
(*b*) Isotropic material is apparently not as abundant as in previous samples.
(*c*) No siderite or rhodochrosite was observed. One or two grains of calcite are present (probably less than 2%).
(*d*) Nearly as much quartz is present as in D-1. It is decidedly coarser grained but still of microscopic dimensions (maximum size about 0.15 mm.; average size estimated at 0.05 mm.).
(*e*) Apparently fewer of the minor constituents are present than in the other samples.

Sample K-1 (Kentucky flint).

(*a*) Clay minerals occur as extremely minute plates. Probably a smaller amount present than in any other of the samples examined.
(*b*) Isotropic (amorphous, colloidal aggregates?) material with index about 1.57, is probably more abundant than in other samples.
(*c*) A small amount of siderite or rhodochrosite (probably less than 2%) is present.
(*d*) There is very little quartz present, probably less than 5%.
(*e*) Minor constituents are present in small amounts.

(2) Chemical Analysis[13] The chemical analyses of the fire clays are given in Table I and that of the fireclay brick in Table II.

TABLE I—CHEMICAL ANALYSES OF FIRE CLAYS

Laboratory key letter	Ignition loss (%)	SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	TiO_2 (%)	CaO (%)	MgO (%)	Total (%)
A-1	14.30	43.32	35.72	3.26	2.02	0.18	0.40	99.20
A-2	14.08	44.64	35.84	2.39	1.77	0.26	0.52	99.50
B-1	13.26	43.38	37.97	1.39	2.12		0.31	98.43
B-2	14.58	43.06	37.84	2.14	1.84	0.12	0.04	99.62
B-3	8.16	58.68	24.95	2.39	1.70	0.19	0.70	96.77
C-1	13.78	42.74	39.18	1.01	2.33		0.29	99.33
C-2	10.86	50.38	30.87	2.56	2.27	0.32	0.30	97.56
D-1	12.34	51.82	32.09	1.24	1.63		0.58	99.70
E-1	14.06	45.98	37.12	0.88	1.90	0.12	0.29	100.35
G-1	14.32	47.09	36.25	0.75	1.89	0.44	0.06	100.80
H-1	7.42	70.29	19.46	0.88	2.02	0.22	0.03	100.32
H-2	14.36	46.36	35.43	1.87	1.57	0.44	0.46	100.50
H-3	1.62	91.52	4.65	0.28	0.67	0.26	0.31	99.31
H-4	2.86	87.68	7.33	1.06	1.25	0.38	0.14	100.70
H-5	12.82	52.26	32.30	0.84	1.72	0.26	0.02	100.02
H-6	8.14	68.20	21.37	0.78	1.63	0.34	0.12	100.58
I-1	11.62	51.42	32.80	0.93	2.33		0.52	99.62
I-2	13.66	44.66	37.58	1.33	1.53	0.66	0.15	99.67
I-3	10.62	53.50	29.82	1.95	1.73	0.23	0.16	98.01
K-1	14.86	42.50	39.68	0.76	2.34		0.12	100.26
K-2	12.28	47.00	33.41	2.59	2.00	0.48	0.32	98.08
M-1	13.68	44.56	38.19	1.12	2.21	0.14	0.10	100.00
M-2	11.46	45.76	35.67	1.95	1.72	0.30	0.64	97.50
P-1	0.28	97.48	0.72	0.14	0.46	0.16	0.32	99.56
Q-1	13.32	42.32	39.63	0.84	1.81	0.68	0.50	99.10
R-1	12.06	52.78	29.90	2.37	1.07	0.04	1.20	99.42
R-2	14.66	44.46	37.31	1.13	2.76	0.20	0.12	100.64
R-3	7.22	72.78	18.94	0.65	0.61	0.23	0.14	100.57
T-1	10.92	60.26	25.28	1.62	1.28	0.38	0.16	99.90

TABLE II—ANALYSES OF FIRE BRICK

Key letter of brand	Chemical Analysis							Rational Analysis		
	Al_2O_3 (%)	SiO_2 (%)	Fe_2O_3 (%)	TiO_2 (%)	CaO (%)	MgO (%)	Ignition loss (%)	Clay (%)	Uncombined quartz (%)	Flux (%)
A	40.90	51.48	2.79	2.45		0.58	0.24	90.40	2.94	6.66
B	39.08	51.50	3.15	2.53		0.46	0.44	86.80	4.90	8.28
C	43.06	50.00	1.02	2.80	0.54	0.41	0.26	93.50[a]	0.00	5.96
D	35.31	58.96	1.99	2.02	0.50	0.30	0.16	79.40	15.52	5.10
E	32.11	61.54	1.70	1.89	0.50	0.29	0.40	72.85	21.35	5.70
F	34.54	59.64	1.71	1.97	0.52	0.63	0.26	77.80	16.95	5.18
G	31.91	63.48	1.26	1.97			0.26	71.80	23.10	4.12
H	17.18	80.12	1.02	1.76	0.42	0.32	0.22	40.95	56.52	2.55
I	38.18	54.66	1.89	2.25	0.40	0.05	0.36	85.05	8.62	6.32
J	33.40	57.86	2.26	2.20	0.58	1.18	0.50	75.60	16.65	7.82
K	36.56	54.98	2.84	2.52	0.48	0.59	0.24	81.81	10.62	7.47
L	39.82	54.00	2.01	2.51	0.36	0.61	0.20	88.22	6.32	5.42
M	38.99	51.56	2.45	2.98	0.52	0.26	0.20	86.65	5.03	8.31
N	34.50	58.44	2.40	2.06	0.14	0.40	0.12	77.78	15.95	6.30
P	27.08	69.12	1.64	1.40	0.50	0.25	0.10	62.42	34.04	3.47
Q	46.76	47.12	1.43	2.45	1.24	0.49	0.18	89.40[b]	0.00	4.77
R	37.62	56.48	1.96	2.50	0.72	0.56	0.24	83.99	10.82	5.21

[a] 0.52% uncombined Al_2O_3.
[b] 5.83% " "

[13] Chemical analyses made by J. F. Klekotka.

A study of the data shows a wide variation in the composition of these materials. As shown by the analyses of samples H-3, H-4, and P-1 (Table I), these materials are composed largely of silica.

The mineralogical constitution of the several brands of fire brick, as computed from their chemical analyses,[14] are shown in Table II.

Only two of the brands (C and Q) show an excess of alumina, although a number of brands show only a slight excess of uncombined quartz. The flux content which appears to be rather high in a number of cases may be

TABLE III

TYPE OF CLAYS: ORIGIN, ABSORPTION, AND P.C.E.

Laboratory letter	Type of clay	Origin	P.C.E.	Absorption in % of dry weight after firing at 1160°C for 3 hrs.
A-1	Flint	Kentucky	32	11.6
A-2	Plastic	"	32	10.6
B-1	Semiflint	Pennsylvania	33	12.3
B-2	Flint	"	33*	16.7
B-3	Plastic	"	26	7.8
C-1	Flint	"	33	16.0
C-2	Plastic	"	28–29	6.0
D-1	Semiflint	Missouri	31–32	7.7
E-1	"	"	30	13.8
G-1	Plastic		32	26.3
H-1	"	New Jersey	30	20.7
H-2	"	"	32	9.6
H-3	Silica sand	"	32	
H-4	" "	"	32	
H-5		"	33	21.0
H-6	Plastic	"	30	20.0
I-1	Semiflint	Kentucky	31	13.0
I-2	Flint	"	33	14.6
I-3	Plastic	Ohio	30	11.5
K-1	Flint	Kentucky	32	17.6
K-2	Plastic	"	32	7.9
M-1	Flint	Pennsylvania	32–33	9.7
M-2	Plastic	"	32–33	22.3
P-1	Crushed quartz	California	33	
Q-1	Flint	Missouri	33	10.7
R-1	Plastic	California	30–31	10.4
R-2	Kaolin	"	32–33	9.2
R-3	Siliceous	"	33	26.1
T-1	Plastic	Illinois	30	8.0

* Higher than cone 33.

partially attributed to the percentage of titanium oxide present, which was overlooked in some earlier analyses of fireclay refractories.[14]

(3) **Absorption** The data of absorption of the brick "as received" from the manufacturer and also on the brick after reheating them for five hours at 1400°C are given in Table IV. The absorption for the specimens "as received" ranges from 5.2% for the lowest to 17.6% for the highest, and for the reheated specimens from 3.0% for the lowest to 17.1% for the highest. Although it is appreciated that firing in a labora-

[14] Bur. Stand., *Tech. Paper*, No. 279 describes in detail the method used.

tory kiln and firing in an industrial kiln may affect the physical properties of a refractory somewhat differently, the absorption values before and after the reheating give a fair indication of the heat treatment the various fireclay brick may have received in the manufacturing process.

Data of absorption of fire clays have been determined only after firing the material at 1160°C for three hours (cone 4). The data are included in Table III simply to make possible a comparison of the clays with one another.

(4) Pyrometric Cone Equivalents Table III gives the P.C.E. values for all the material entering into the various brands of brick. All materials, with the exception of samples B-3 and C-2 (Pennsylvania plastic fire clays), have a P.C.E. of 30 or above.

TABLE IV

MANUFACTURING METHODS AND CERTAIN PHYSICAL PROPERTIES OF FIRE BRICK

Laboratory key letter of brand	Method of manufacture [a]	P.C.E.	Absorption in per cent of weight of dry brick		Number of quenchings required to cause failure. Fire brick heated to 1400°C for 5 hours [b]				Average number of quenchings in the 4-in. dip tests
			As received	After firing 5 hours at 1400°C	2″ dip	4″ dip	4″ dip	4″ dip	
A	HM	33+	14.1	10.7	45	49	43		46
B	HM	33+	10.9	9.5	38	16	6	9	10
C	DP	33+	9.6	8.1	45	29	32		31
D	DP	31–32	6.7	5.3	8	34	7	10	17
E	DP	31–32	5.2	6.6	5	18	16	11	15
F	SM	31	7.0	3.0	9	11	2	2	5
G	HM repress	32	17.6	16.1	11	8	5		7
H	HM	32	16.3	17.1	12	6	3	6	5
I	HM	33	10.7	8.9	26	24	15	11	17
J	SM	28–29	8.3	3.8	6	8	6		7
K	SM	32	8.2	6.8	15	10	12		11
L	HM	33	8.2	6.8	32	17	18		18
M	HM	33	11.7	11.4	19	14	11		13
N	SM	32	5.5	4.8	4	6	5		6
P	SM repress	30	13.8	12.4	4	8	4		6
Q	DP	34	7.2	6.9	>50	49	>41		>45
R	HM repress	33	13.6	12.6	3	8	8	4	7

[a] HM, SM, DP refer to handmade, stiff-mud, dry-press processes, respectively.
[b] Only one end heated at 1400°C for 5 hours.

Table IV gives the P.C.E. values as determined on the 17 brands of fireclay brick. The data show that with the exception of samples designated "J" and "P," all the brands of fireclay brick have a P.C.E. of 31 or above.

(5) Thermal Spalling Test The results of the various spalling tests are given in Table IV. Five samples of each brand of brick were tested for resistance to spalling in the test requiring an immersion in water of four inches. The test was made a second time on all brands of brick and those brands showing great differences in results between these two tests were tested a third time. The average of the

several tests gives a range in number of cycles to cause failure, of from five for those showing the least resistance to over forty-six for those having the greatest resistance.

The number of cycles required to cause spalling in the modified spalling test, in which only one end of the brick was heated in the reheat test and a two-inch immersion was used, ranged from a minimum of three to a maximum of over fifty.

Comparison of the results obtained in the two-inch against four-inch immersion tests shows a decided lack of correlation between the two tests. In several instances very little difference is noted in the number of cycles required to cause failure; in some cases the number of cycles required to cause spalling is much greater with the two-inch immersion and in still others the reverse is true.

(6) Sizes of Grog Grog is fired clay, either as such or in the form of broken brick, discarded saggers, or other cast-off refractory shapes. It is usually ground or crushed and may or may not be screened to specific sizes for use. In those plants where grog is an essential constituent of the product, it is obtained as a rule by grinding or crushing broken or discarded fire brick. The analyses made of the raw batch materials furnished by manufacturers of fire brick showed that not all of them use grog in their product. Those manufacturers, however, who use considerable quantities of flint clay in their batch composition grind the flint clay to a desired size. Since the particles of flint clay do not readily slake, they probably serve a purpose similar to that of grog. A macroscopic examination of all the grogs or grog substitutes remaining after washing the samples of batch material on a 200-mesh sieve resulted in classifying the various compositions as follows:

(1) Largely flint clay or flint and semiflint clays with varying percentages of grog.

(2) Entirely flint clay or flint and semiflint clays.

(3) Large percentage of quartz with varying proportions of grog.

The appearance of 14 samples of grogs or grog substitute particles indicates that 13 were crushed and only one was ground.

If it is arbitrarily assumed that the material which passes a 200-mesh sieve is clay substance, and the material which does not pass the sieve is grog, then the grog content of the batches as received ranges from 40 to 80% of the raw brick batch.

Table V shows the respective percentages of grog retained on various mesh sieves and also the percentages of grog and clay in the raw brick batches.

(7) Thermal Expansion (*a*) *Fire Clays:* The thermal expansions of the 24 clays and of the five samples of sand and quartz were determined from room temperature to 900°C. Specimens

made from these materials, with the exception of three of the silica sands, were fired at 1400°C for five hours. They may be classified by thermal expansion behavior into five groups as follows:

(1) Eleven have a high rate of expansion below 200°C and a somewhat less and more uniform one between approximately 200°C and 900°C. The curves indicate that any free silica present is either in the form of tridymite or cristobalite. Clays A-1, B-2, D-1, E-1, G-1, H-2, I-1, I-2, K-1, R-2, T-1 belong in this group.

(2) Four have a high rate of expansion below 200°C and also between approximately 540°C and 600°C. These curves show that quartz, cristobalite, and tridymite are all present in the clays. The expansion curves, however, indicate the presence of only a small amount of quartz. Samples R-3, H-1, H-5, and H-6 belong in this group.

TABLE V

SIEVE ANALYSIS OF GROGS OR GROG SUBSTITUTES USED IN 14 RAW FIRECLAY BRICK BATCHES

Sample key letter	Per cent passing and retained on sieves							
	No. 4 mesh	4–10	10–20	20–40	40–100	100–200	Through 200	Total grog*
A	2.30	17.20	21.40	11.50	11.00	4.05	32.55	67.45
B		22.00	21.20	9.40	9.80	3.40	34.20	65.80
C		9.75	33.25	16.25	15.75	5.37	19.60	80.40
D & N		1.25	18.75	22.75	20.75	6.00	30.50	69.50
E & F		0.25	18.50	20.65	20.50	7.00	30.60	69.40
G	0.25	11.00	11.62	7.12	13.12	5.75	51.10	48.90
H	1.12	2.64	9.50	8.25	12.75	8.74	57.00	43.00
I		9.75	28.30	12.87	11.50	3.87	33.75	66.25
J		1.50	17.75	11.28	8.62	2.25	58.60	41.40
K & L		8.75	24.25	11.00	11.00	4.87	40.10	59.90
M	0.50	18.85	18.75	8.75	10.00	7.50	39.40	60.60
P		6.20	7.90	4.40	18.00	6.20	57.30	42.70
Q		1.50	19.90	39.40	14.50	13.70	11.00	89.00
R		7.50	15.38	8.50	13.25	4.63	50.70	49.30

* Material that did not pass a 200-mesh sieve was considered as grog.

(3) Three have a comparatively uniform rate of expansion throughout the range observed except for an increased expansion at approximately 575 to 600°C. These curves indicate that all silica is present in the form of free quartz. Samples H-3, H-4, and P-1 are classed in this group.

(4) Three clays have a uniform expansion from room temperature to approximately 750°C. At this temperature the expansion per degree increases up to approximately 850°C after which it gradually decreases. The clays in this group are all of the so-called plastic type and it is quite possible that after firing for five hours at 1400°C sufficient glass is present to cause this change in the rate of expansion more or less typical of some glasses.[15] Samples B-2, C-2, and I-3 belong to this group.

[15] Bur. Stand., *Sci. Paper*, No. 393.

TABLE VI

TOTAL LINEAR THERMAL EXPANSION PER UNIT LENGTH AT TEMPERATURES INDICATED OF FIRE CLAYS FIRED AT 1400°C FOR 5 HOURS

Laboratory key letter	Temperature °C										Classed according to type of expansion in group
	100	200	300	400	500	550	600	700	800	900	
A-1	0.000484	0.001773	0.002254	0.002804	0.003352	0.003607	0.003899	0.004429	0.004979	0.005548	1
A-2	0.000310	0.000807	0.001223	0.001697	0.002105	0.002430	0.002736	0.003274	0.003847	0.004413	5
B-1	0.000216	0.000597	0.001025	0.001454	0.001930	0.002172	0.002412	0.002847	0.003407	0.003905	5
B-2	0.000500	0.001094	0.001488	0.001927	0.002385	0.002559	0.002835	0.003992	0.003741	0.004227	1
B-3	0.000194	0.000562	0.000900	0.001285	0.001697	0.001878	0.002184	0.002502	0.003164	0.003884	4
C-1	0.000219	0.000559	0.000890	0.001325	0.001762	0.001976	0.002234	0.002659	0.003201	0.003717	5
C-2	0.000240	0.000560	0.000926	0.001351	0.001815	0.002024	0.002450	0.002687	0.003175	0.003719	4
D-1	0.000654	0.002730	0.003230	0.003791	0.004358	0.004637	0.004915	0.005461	0.006019	0.006484	1
E-1	0.000612	0.002256	0.002772	0.003305	0.003835	0.004102	0.004370	0.004899	0.005462	0.005972	1
G-1	0.000581	0.002340	0.002879	0.003456	0.004038	0.004318	0.004662	0.005189	0.005688	0.006093	1
H-1	0.000826	0.003122	0.004219	0.004879	0.005650	0.005790	0.005860	0.006496	0.007152	0.007373	2
H-2	0.000437	0.001329	0.001778	0.002265	0.002763	0.003011	0.003283	0.003797	0.004375	0.004880	1
H-3*	0.000820	0.002321	0.003810	0.006258	0.008915	0.011020	0.015300	0.015450	0.015400	0.015214	3
H-4*	0.000913	0.002555	0.004253	0.006578	0.009577	0.010586	0.015000	0.015100	0.015050	0.014980	3
H-5	0.000673	0.002701	0.003346	0.003911	0.004496	0.004824	0.005270	0.005925	0.006318	0.006623	2
H-6	0.000723	0.004693	0.006128	0.006798	0.007494	0.007783	0.008224	0.008766	0.009064	0.009290	2
I-1	0.000555	0.002263	0.002806	0.003329	0.003872	0.004131	0.004426	0.004960	0.005363	0.005766	1
I-2	0.000447	0.001244	0.001710	0.002189	0.002657	0.002926	0.003198	0.003737	0.004322	0.004911	1
I-3	0.000266	0.000787	0.001118	0.001568	0.001966	0.002150	0.002388	0.002883	0.003352	0.003731	4
K-1	0.000707	0.002182	0.002646	0.003198	0.003743	0.004181	0.004321	0.004837	0.005375	0.005875	1
K-2	0.000226	0.000628	0.001015	0.001440	0.001900	0.002129	0.002371	0.002866	0.003546	0.004118	5
M-1	0.000241	0.000690	0.001092	0.001500	0.001968	0.002219	0.002475	0.002976	0.003577	0.004298	5
M-2	0.000252	0.000651	0.001053	0.001519	0.001993	0.002242	0.002494	0.002879	0.003613	0.004392	5
P-1*	0.000896	0.002347	0.003886	0.006121	0.008570	0.010610	0.014840	0.014900	0.014860	0.014850	3
Q-1	0.000235	0.000673	0.001062	0.001552	0.002022	0.002271	0.002540	0.003089	0.003917	0.004530	1
R-1	0.000235	0.000666	0.001042	0.001462	0.001897	0.002125	0.002356	0.002798	0.003324	0.003871	5
R-2	0.000735	0.002048	0.002587	0.003125	0.003700	0.003970	0.004348	0.004808	0.005365	0.005308	1
R-3	0.000748	0.003549	0.006194	0.007017	0.007810	0.008247	0.009000	0.009441	0.009671	0.009794	2
T-1	0.000676	0.003571	0.004273	0.004872	0.005490	0.005794	0.006122	0.006717	0.007166	0.007569	1

* Observations made on the raw material which is composed largely of silica and did not sinter at 1400°C.

(5) Eight clays have a uniform expansion throughout the entire range of 20 to 900°C.

The materials tested, therefore, include all those having the several types of expansion due to a substantially quartz-free condition or to the presence of quartz either as such or in one of its allotropic modifications.

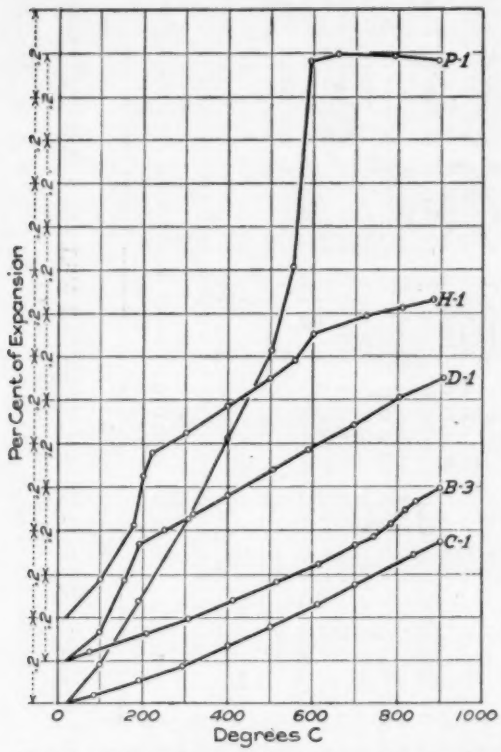

FIG. 3.—Curves showing linear thermal expansions characteristic of different types of fire clays. It should be noted that, in order to avoid overlapping, the curves have not all been drawn from a common origin.

Curves, showing the thermal expansion behavior from 20 to 900°C of materials representative of each of the foregoing groups, are given in Fig. 3.

The total linear expansion values per unit length from 100 to 900°C at 100°C intervals and also the value obtained at 550°C are given in Table VI. The initial measurement of the specimen was made at approximately 20°C.

(*b*) *Fireclay Brick:* The linear thermal expansions of the fireclay brick were observed from approximately 20 to 1000°C on a specimen cut from each of the 17 brands of brick, (*a*) as received; (*b*) refiring five hours at 1400°C; (*c*) refired again at 1500°C for five hours, and (*d*) an additional refiring three hours at 1600°C.

The brick may be classified into four groups according to the type of expansion observed on the specimen as received from the manufacturer.

(1) Three brands, C, M, and Q, were found to have a comparatively uniform rate of expansion.

(2) Three brands, D, N, and R, had a high rate of expansion below 200°C and a uniform rate from approximately 200 to 1000°C.

(3) One brand only, J, showed a high expansion between 550°C and 600°C, indicating an inversion of alpha to beta quartz.

(4) The other ten brands show an increased expansion both below

200°C and also between approximately 550°C and 600°C, although the alpha to beta quartz inversion is comparatively slight in the case of seven brands in this group.

Thermal expansion curves plotted from observations on the 17 brands of fireclay brick, as received from the manufacturer, are shown in Fig. 4.

Check determinations were made on six specimens of fire clay and eleven specimens of fireclay bricks. The greatest variation in the data obtained on the same body was less than $\pm 2.5\%$.

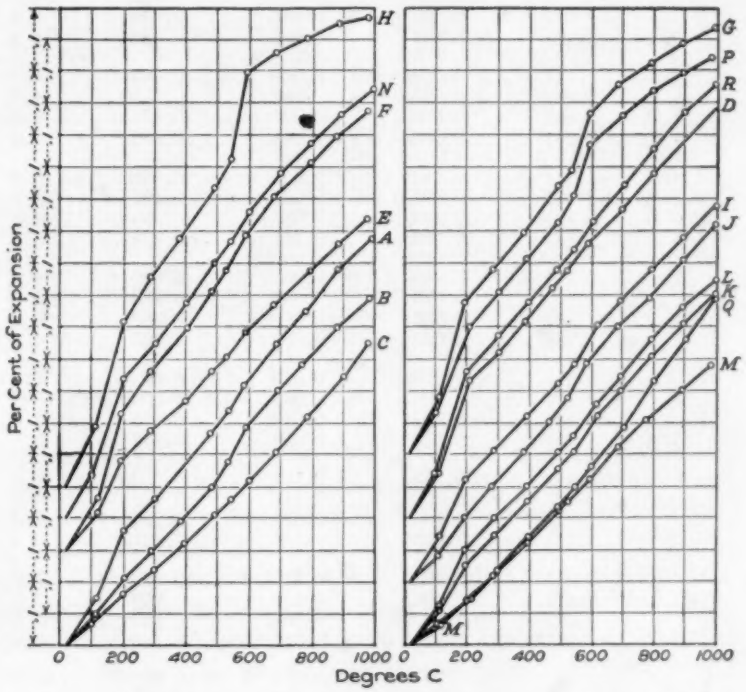

FIG. 4.—Curves showing linear thermal expansions of 17 brands of fire clay brick as "received" from the manufacturer. To avoid overlapping, the curves have not all been drawn from a common origin.

(*c*) *Effect of Temperature of Firing on Thermal Expansion:* The changes in the physical composition of the brick brought about by reheating them at 1400°C, 1500°C, and 1600°C are well illustrated by the data outlined on the linear thermal expansion.

Table VII presents expansion data for brick "as received" and after reheating in the laboratory kiln at 1400°C, 1500°C, and 1600°C. The total linear expansions per unit length between 100°C and 200°C, 500°C and 600°C, and 20 to 1000°C, together with the coefficient of expansion between

TABLE VII

EXPANSION IN PER CENT OF UNIT LENGTH AND COEFFICIENT OF EXPANSION OF FIRE BRICK

Brand	Temperature of firing[a]	Range of temperature (°C)			Coefficient of expansion[b]
		100–200	500–600	20–1000	20–1000°C
A	(1)	0.116	0.069	0.635	6.5
	(2)	0.053	0.053	0.473	4.8
	(3)	0.048	0.050	0.485	5.0
	(4)	0.046	0.046	0.440	4.5
B	(1)	0.064	0.089	0.541	5.5
	(2)	0.038	0.047	0.421	4.3
	(3)	0.043	0.046	0.419	4.3
	(4)	0.047	0.059	0.483	4.9
C	(1)	0.059	0.058	0.462	4.7
	(2)	0.035	0.046	0.410	4.2
	(3)	0.035	0.046	0.412	4.2
	(4)	0.038	0.045	0.402	4.1
D	(1)	0.141	0.051	0.603	6.4
	(2)	0.091	0.045	0.497	5.1
	(3)	0.033	0.038	0.390	4.0
	(4)	0.028	0.041	0.358	3.7
E	(1)	0.096	0.061	0.530	5.4
	(2)	0.079	0.046	0.486	5.0
	(3)	0.035	0.040	0.365	3.7
	(4)	0.042	0.052	0.398	4.1
F	(1)	0.150	0.078	0.698	7.1
	(2)	0.093	0.043	0.509	5.2
	(3)	0.035	0.044	0.355	3.6
	(4)	0.028	0.039	0.347	3.5
G	(1)	0.153	0.121	0.680	6.9
	(2)	0.153	0.111	0.642	6.5
	(3)	0.166	0.055	0.716	7.3
	(4)	0.045	0.044	0.424	4.3
H	(1)	0.177	0.218	0.770	7.8
	(2)	0.190	0.175	0.739	7.5
	(3)	0.205	0.068	0.730	7.5
	(4)	0.225	0.047	0.740	7.6
I	(1)	0.098	0.077	0.590	6.1
	(2)	0.047	0.055	0.492	5.0
	(3)	0.044	0.051	0.442	4.5
	(4)	0.047	0.050	0.421	4.3
J	(1)	0.062	0.085	0.569	5.7
	(2)	0.036	0.041	0.439	4.4
	(3)	0.035	0.042	0.399[c]	4.5
	(4)	0.031	0.051	0.466	4.7
K	(1)	0.079	0.067	0.546	5.6
	(2)	0.055	0.050	0.412	4.2
	(3)	0.038	0.051	0.432	4.5
	(4)	0.038	0.058	0.446	4.5
L	(1)	0.096	0.065	0.571	5.9
	(2)	0.036	0.045	0.341[c]	4.0[c]
	(3)	0.038	0.042	0.421	4.3
	(4)	0.038	0.050	0.441	4.5

Brand	Temperature of firing[a]	Range of temperature (°C) 100–200	500–600	20–1000	Coefficient of expansion[b] 20–1000°C
M	(1)	0.038	0.052	0.472	4.8
	(2)	0.037	0.051	0.433	4.4
	(3)	0.039	0.045	0.437	4.5
	(4)	0.039	0.047	0.438	4.3
N	(1)	0.155	0.074	0.673	6.9
	(2)	0.110	0.054	0.574	5.9
	(3)	0.037	0.046	0.384[c]	4.4[c]
	(4)	0.037	0.043	0.450	4.6
P	(1)	0.127	0.117	0.632	6.5
	(2)	0.098	0.101	0.546	5.6
	(3)	0.066	0.058	0.542	5.5
	(4)	0.054	0.042	0.487	5.0
Q	(1)	0.043	0.061	0.544	5.5
	(2)	0.033	0.055	0.500	5.1
	(3)	0.037	0.054	0.493	5.0
	(4)	0.035	0.056	0.520	5.3
R	(1)	0.151	0.068	0.678	6.9
	(2)	0.105	0.062	0.612	6.3
	(3)	0.040	0.050	0.405	4.1
	(4)	0.035	0.045	0.447	4.6

[a] (1) Data obtained on brick as received from manufacturer.
(2) Data " after firing 5 hours in laboratory kiln at 1400°C
(3) Data " " " 5 " " " " " 1500°C
(4) Data " " " 3 " " " " " 1600°C
[b] To be multiplied by 10^{-6}.
[c] Data obtained at 900°C.

the latter temperatures are tabulated. The data shown for these temperature ranges illustrate the effect on the thermal expansion of the refractory produced by progressively increased firing temperatures.[16] With few exceptions the expansion decreases as the temperature of firing is increased.

These data show that it would be very misleading to consider an average coefficient of expansion for a single range as large as from 20 to 1000°C as representative of the expansion behavior of the material since it does not indicate whether the rate throughout this range is uniform or highly irregular. A typical example of this is illustrated by the data from Brand H. The variation in total expansion from 20 to 1000°C is comparatively small with change of firing temperatures although the change in this property is quite large between 100°C and 200°C and especially so between 500°C and 600°C. In addition, expansion increased between 100°C and 200°C and decreased between 500°C and 600°C.

The change in total expansion because of progressive heat treatment ranges from a low of approximately 5% to a high of 50%.

[16] Thermal expansion data similar to those obtained in this investigation were found by Miehr, Kratzert, and Immke, described in their paper, "Influence of Firing on the Chemical and Physical Properties of Refractory Clays," *Tonind.-Ztg.*, **52** [16] 280–82 (1928).

Those brands of brick showing an excess of alumina in their rational composition[17] or only a small per cent of free silica as computed from the chemical analyses, showed the least change in expansion after the heating treatment. Very little change was apparent in the expansion data of these brands after the firings at either 1400°C, 1500°C, or 1600°C. The greatest change in this property appears to have been in those brands having uncombined silica exceeding 10%.

Typical curves showing the change in thermal expansion due to progressive heat treatment of the various types of brick are shown in Figs.

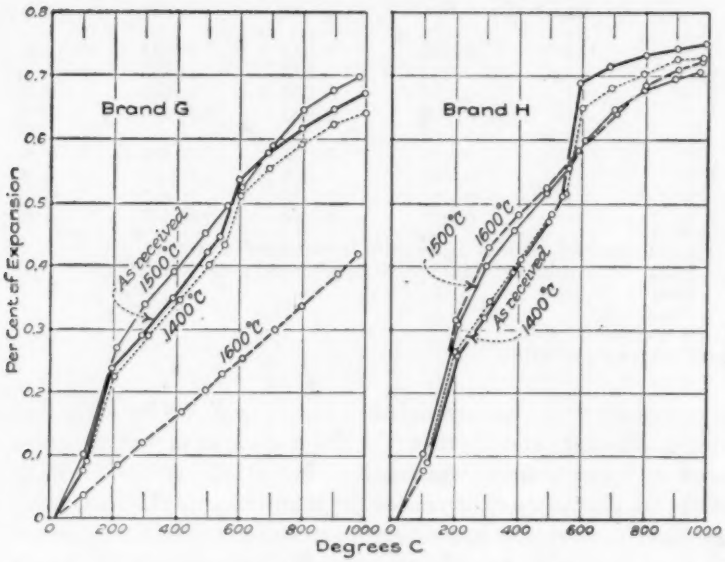

FIG. 5.—The effect on the thermal expansions of highly siliceous fire brick caused by progressively increasing firing temperatures.

5 and 6. The curves shown in these figures illustrate the rates of expansion as well as the total linear thermal expansion from approximately 20 to 1000°C that are typical of the various brands of fireclay brick manufactured in this country. The data, from which the points on these curves were computed, were determined on brick of widely different expansion behavior such as those of Brand H, having a high and irregular rate of expansion below 600°C; to those of Brand Q having a moderate but uniform rate throughout the range observed.

These data indicate that, in those brick showing high rates of expansion due to inversions both of cristobalite and quartz, there is first, solution of

[17] Bur. Stand., *Tech. Paper*, No. 279, p. 126.

the latter form of silica and then of the former. The linear thermal expansion curves of 14 of the 17 brands of fireclay brick when tested "as received" were irregular. With but one exception (Brand H) after heating these bricks at either 1400°C, 1500°C, or 1600°C the expansion became uniform and lower. If heated sufficiently, all fireclay brick of the quality included in this study will have practically the same type and rate of thermal expansion regardless of the nature of the materials used originally in their manufacture. Brand H, an exception, is a highly siliceous brick.

A petrographic examination of Brands G and H, after the final reheating at 1600°C showed the materials to consist of only well-developed crystals of mullite embedded in glass.

Since these data show that the thermal expansions of the majority of brick decrease as the temperature of firing is increased, all internal stresses caused by large differences in thermal expansion behavior of the fire clays making up the brick might be greatly reduced, if not entirely eliminated.

(*d*) *Fireclay Brick and Fire Clays Entering into Their Manufacture:* As previously stated, the manufacturers furnished the names of the various clays entering into the manufacture of their respective brands of brick. The thermal expansion curves, therefore, show the results from blending the clays as illustrated by any particular brand of brick. Inasmuch as the propor-

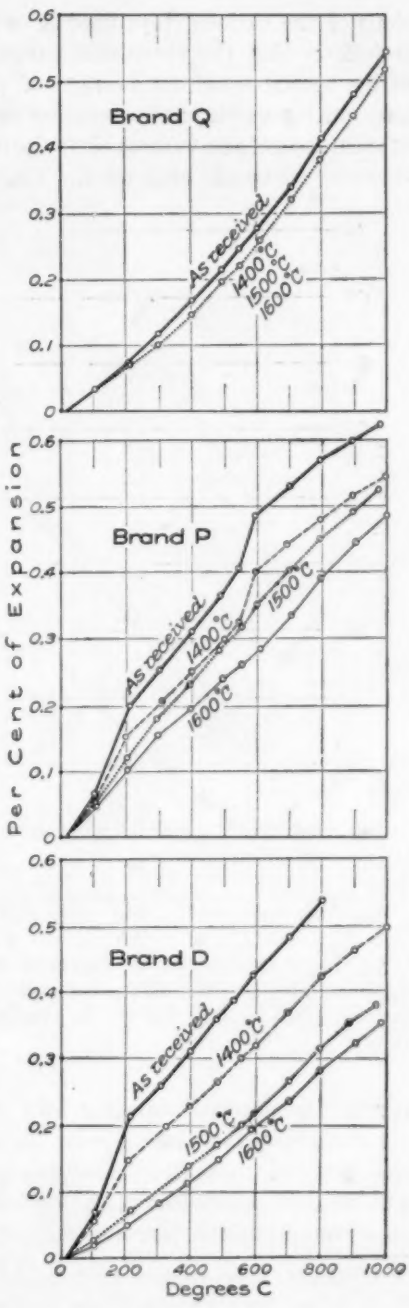

FIG. 6.—Effect on the thermal expansions of fireclay brick, not of highly siliceous type, caused by progressively increasing firing temps.

tions of the various clays used in any particular batch are not the same, it follows that the expansion curve of the fireclay brick will not necessarily be the weighted average of those of the individual clays. It is also quite possible that a reaction or physical change occurs between the constituents of the various clays during heating which may have an appreciable effect on the expansion. The curves shown in Figs. 7 and 8 represent data computed from observations made on the material after it had been fired at 1400°C for five hours.

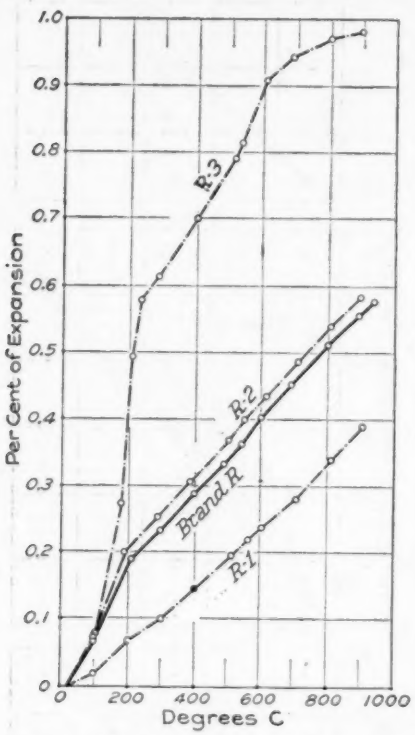

FIG. 7.—Thermal expansion curves of the materials entering into the manufacture of fireclay brick R and that of the finished product.

The thermal expansions of each of the three materials (broken lines) entering into the composition of Brand R as well as that of the brick (full line) are shown in Fig. 7. These curves illustrate the large differences which may occur in expansion behavior of the individual materials entering into one composition and the resultant effect on the final product.[18] The expansion of the brick is approximately the computed average of those of the materials entering into its composition based on the percentage of each material present. It would be logical to assume that such large differences in the thermal expansions between materials constituting a refractory would cause inter-structural stresses greatly affecting the life of the product.

In contrast to the expansion curves for materials entering into the manufacture of Brand R (Fig. 7) curves obtained on the different clays in Brand C as well as the expansion curve of the finished product are shown in the lower section of Fig. 8. The thermal expansions of the two clays used in this brick are very nearly alike; the expansions are uniform throughout the range observed and the

[18] Willi M. Cohn discusses the behavior of minerals and ceramic bodies on heating in his paper, "Some Factors Influencing the Thermal Properties of Minerals and Products of the Ceramic Industry," *Jour. Amer. Ceram. Soc.*, **11** [5], 296–306 (1928).

total expansions are low for fireclay materials. The expansion data observed on the brick (shown as a full line in the graph) are practically the same as those for the two clays. The expansion behavior of the clays as well as that of the brick might be considered as approaching the ideal since the internal stresses should be at a minimum.

The curves in the center section of Fig. 8 are for the two clays (broken lines) and the finished brick, Brand A (full line), made from them. The inflection, below 200°C, in the expansion curve for clay A-1 has completely disappeared in the finished product, the expansion behavior of which closely approaches that of the bonding clay, A-2.

In the upper section of Fig. 8 are the linear expansion curves of the two clays (broken lines) in Brand I and (solid line) for the final product. The curve for the fire brick not only fails to show any sign of an inflection at 200°C, which is quite pronounced in the curve for fire clay I-1, but is appreciably lower than that of either clay from which it is prepared.

(8) Modulus of Elasticity Transverse Strength, and Maximum Elongation

Figure 9 shows the deflections, typical of fireclay brick, corresponding to the various loads applied to brick of Brand C. The stress (load) strain (deformation) curves were deter-

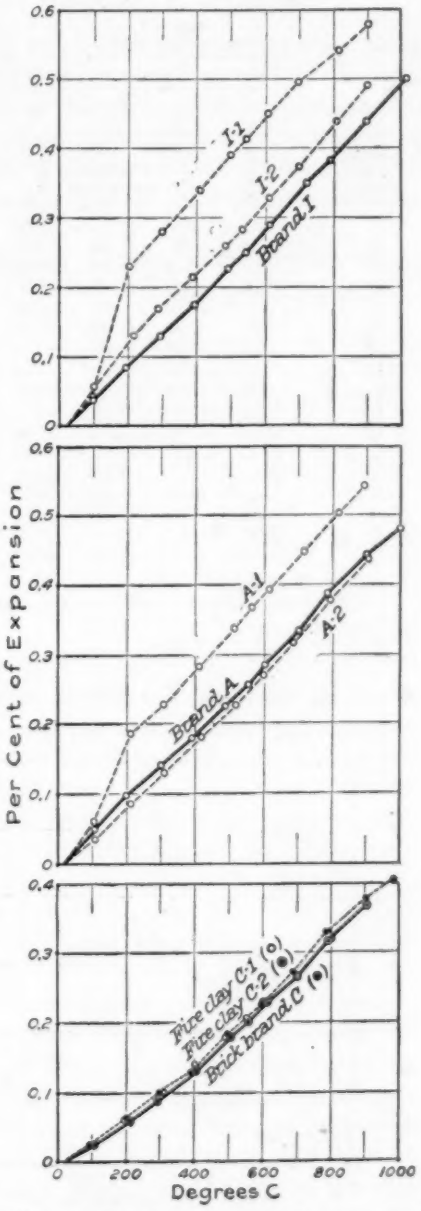

FIG. 8.—Showing the expansion curves of three brands of brick and the clays used in their manufacture.

TABLE VIII

PROPERTIES OF COMMERCIAL FIRECLAY BRICK TESTED AT 20°C

Laboratory key letter of brand	As received from manufacturer: Modulus of Elasticity[a] (lbs./sq. in.)	As received from manufacturer: Modulus of Rupture (lbs./sq. in.)	As received from manufacturer: Maximum elongation[b] (R/E) (%)	After reheating at 1400°C—5 hours: Modulus of Elasticity[a] (lbs./sq. in.)	After reheating at 1400°C—5 hours: Modulus of Rupture (lbs./sq. in.)	After reheating at 1400°C—5 hours: Maximum elongation[b] (R/E) (%)	After reheating at 1500°C—5 hours: Modulus of Elasticity[a] (lbs./sq. in.)	After reheating at 1500°C—5 hours: Modulus of Rupture (lbs./sq. in.)	After reheating at 1500°C—5 hours: Maximum elongation[b] (R/E) (%)
A	631	270	0.04	920	525	0.06	2430	875	0.04
B	1434	640	0.04	1350	380	0.03	2670	560	0.02
C	510	265	0.05	1890	520	0.03	2450	805	0.03
D	974	620	0.06	1520	830	0.06	4040	1485	0.04
E	640	1030	0.16	2670	1415	0.05	8380	2000	0.02
F	2800	1560	0.06	3170	1775	0.06	9490	1575	0.02
G	920	760	0.08	1070	625	0.06	2605	980	0.04
H	250	235	0.09	353	335	0.09			
I	990	590	0.06	2300	885	0.04	3665	1345	0.04
J	2580	1355	0.05	6400	1470	0.02	bloated	bloated	bloated
K	2170	1195	0.05	2700	925	0.03	4995	1230	0.02
L	2145	580	0.03	3145	910	0.03	4440	1485	0.03
M	2110	720	0.03	4500	1210	0.03	6920	1295	0.02
N	3345	1430	0.04	3950	1415	0.04	3635	1420	0.04
P	1665	950	0.06	1950	955	0.05	2930	1230	0.04
Q	2025	915	0.04	2700	1190	0.04	5340	1520	0.03
R	3350	1225	0.04	3720	1285	0.03	4630	1495	0.03

[a] To be multiplied by 10^3.

[b] Maximum elongation of extreme fiber at point of rupture of specimens = $\frac{\text{modulus of rupture}}{\text{modulus of elasticity}} = R/E$

mined on specimens one inch in cross-section and nine inches long, cut from the fire brick. They were placed across an 8-inch span and loaded at the center. All brick were tested at approximately 20°C, (*a*) as received from the manufacturer, (*b*) after reheating at 1400°C, and (*c*) after reheating at 1500°C. The data are given in Table VIII. The decrease in flexibility of the material, as the temperature of firing is raised, is well illustrated in Fig. 9.

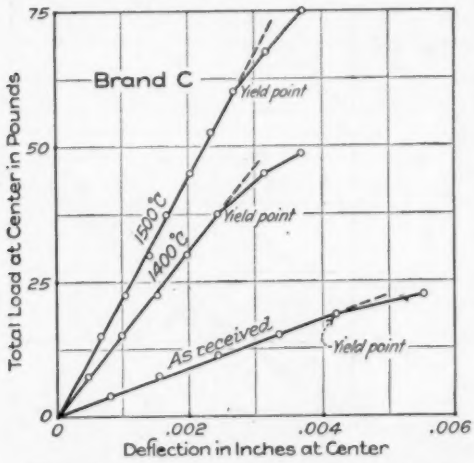

FIG. 9.—Curves showing the typical stress (load) strain (deformation) relationship of fireclay brick as the temperature of firing is increased.

The transverse strengths (moduli of rupture) of the various brands of brick were computed from the loads required to break the specimens

on which the load-deflection curves were determined. The values are shown in Table VIII.

The data show that the modulus of elasticity had increased greatly and that the modulus of rupture had also increased, but not to the same degree as the modulus of elasticity, as the temperature of firing was raised.

The maximum elongation at rupture after the three heat treatments is also given in Table VIII. The maximum elongation of the material had a tendency to decrease as the temperature of firing of the material was raised.

The following table gives the maximum, minimum, and average values of certain properties of brick made by different processes and reheated at 1400°C.

Method of manufacture	Number of brands	Modulus of elasticity (lbs./sq. in.)	Absorption in per cent of dry weight	Failed in quenching test after (cycles)	Linear thermal expansion between 100 to 200°C (%)
Handmade					
Average	8	2,139,000	11.6	15	0.082
Maximum		4,500,000	17.1	46	0.190
Minimum		353,000	6.8	5	0.036
Dry press					
Average	4	2,305,000	6.7	>27	0.059
Maximum		3,140,000	8.1	45	0.079
Minimum		1,520,000	5.3	15	0.033
Stiff mud					
Average	5	3,654,000	6.1*	7	0.078
Maximum		6,400,000	12.4	11	0.110
Minimum		2,050,000	3.0	5	0.055

* Omitting Brand P (12.4%) from this group causes this value to drop to 4.6%.

The bricks manufactured by the stiff-mud process have the highest average modulus of elasticity and the lowest average absorption. These qualities, together with the high rate of thermal expansion between 100°C and 200°C and the possibility of laminated structure, may be the causes of the low resistance to spalling of this type of brick.

The low rate of thermal expansion between 100 to 200°C indicated by the dry-press brick is probably the explanation for the high resistance to spalling shown.

(9) Brick Tested at Several Temperatures

The modulus of elasticity, transverse strength, and maximum elongation after reheating at 1400°C for five hours, were determined at 20°C, 550°C, and 1000°C. The results of these tests (Table IX) with but two exceptions show that both the modulus of elasticity and transverse strength were greater at 550°C than at 20°C.

The percentage increase in modulus of elasticity attending an increase in temperature from 20 to 550°C is greater than the corresponding increase in transverse strength. The effect of higher temperatures on the modulus of elasticity is illustrated in Fig. 10.

The average modulus of elasticity determined at 550°C as compared with that at 20°C of the brick made by the stiff-mud process had increased twice as much as that of the brick made by the handmade process. The increase in the modulus of elasticity of the brick, made by the dry-press method, was intermediate between the increases shown by the brick made by the other two methods. At 1000°C the modulus of rupture had increased moderately and the modulus of elasticity had decreased greatly.

At 550°C the maximum elongation of the extreme fiber had decreased

TABLE IX

PROPERTIES OF COMMERCIAL BRANDS OF FIRE BRICK REHEATED AT 1400°C FOR 5 HOURS

Key letter of brand	Tested at 20°C: Modulus of Elasticity (1000 lbs./sq. in.)	Tested at 20°C: Modulus of Rupture (lbs./sq. in.)	Tested at 20°C: Maximum elongation (%)	Tested at 550°C: Modulus of Elasticity (1000 lbs./sq. in.)	Tested at 550°C: Modulus of Rupture (lbs./sq. in.)	Tested at 550°C: Maximum elongation (%)	Tested at 1000°C: Modulus of Elasticity (1000 lbs./sq. in.)	Tested at 1000°C: Modulus of Rupture (lbs./sq. in.)	Tested at 1000°C: Maximum elongation, using Tangent modulus (%)	Tested at 1000°C: Maximum elongation, using Secant modulus (%)	Tested at 1000°C: Plastic flow (inches) after 1 hour stress (60 lbs./sq. in.)
A	920	525	0.06	2220	710	0.03	333	730	0.22	0.51	0.0008
B	1350	380	0.03	1820	770	0.04	147	640	0.43	1.50	0.0015
C	1890	520	0.03	1890	550	0.03	227	560	0.25	0.44	0.0008
D	1520	830	0.06	2660	1275	0.05	626	1015	0.16	0.45	0.0009*
E	2670	1415	0.05	3640	1610	0.04	674	2010	0.30	0.40	0.0012
F	3170	1775	0.06	8400	2520	0.03	2372	3320	0.14	1.65	0.0002
G	1070	625	0.06	1400	850	0.06	894	1275	0.14	0.20	0.0005
H	353	335	0.09	610	450	0.07	426	695	0.16	0.29	0.0005
I	2300	885	0.04	2840	1140	0.04	424	810	0.19	0.32	0.0008*
J	6400	1470	0.02	6750	2100	0.03	1217	2620	0.22	0.69	0.0047
K	2700	925	0.03	4760	1355	0.03	331	2750	0.83	0.90	0.0042
L	3145	910	0.03	3520	1390	0.04	531	1390	0.26	0.47	0.0007
M	4500	1210	0.03	5025	1550	0.04	410	2320	0.57		0.0006
N	3950	1415	0.04	4400	1650	0.04	1032	1525	0.12	0.16	0.0001
P	1950	955	0.05	1950	980	0.05	808	1375	0.17	0.27	0.0004
Q	2700	1190	0.04	3830	1200	0.03	614	1135	0.18	0.60	0.0002
R	3720	1285	0.03	5200	1620	0.03	1649	1550	0.09	0.17	0.0016

* These values were obtained using a stress of approximately 120 lbs./sq. in.

when compared with that obtained at 20°C. The formula for computing the outer fiber deformation is based on a linear relationship of the load-deflection curve. At 1000°C this relationship was not found to be linear; therefore, the secant modulus of elasticity was computed and this value substituted in the formula for determining maximum strain values at 1000°C.[19]

Table IX shows the maximum elongation values as computed, using either the tangent or secant modulus. It is believed that the values obtained using the secant modulus represent more nearly the true deformation of the clays at 1000°C.

[19] Maximum strain values at 1000°C of clay bodies are discussed in detail in the Fourth Progress Report of the Sagger Investigation (see footnote 9).

A number of the test specimens of fireclay brick were found to be defective, as evidenced by the rupture occurring at a point other than approximately the middle of the 8-inch span. In such cases the required data were determined on a second specimen. Check determinations of moduli of elasticity and rupture were made on ten specimens and the results procured on the same body varied in the majority of cases less than 10%. The two values obtained for each material are given in Table X.

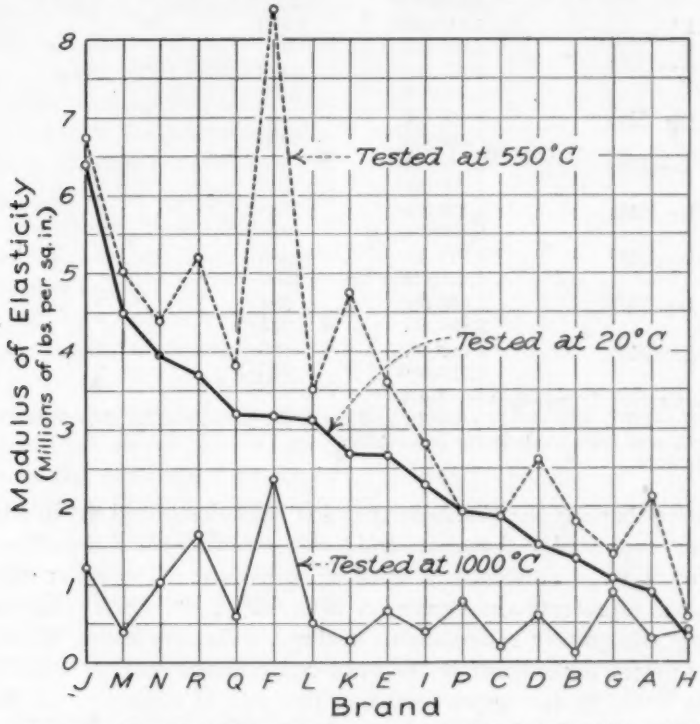

FIG. 10.—The effect of temperature on the modulus of elasticity of 17 brands of fireclay brick.

(10) Some Reasons for Variation in Resistance to Thermal Shock of the Same Brand of Brick

The individual brick in each set varied considerably in the number of quenchings required to produce failure. Two bricks which had been subjected to this test and which showed a great difference in spalling resistance were therefore selected from one set of each of two different brands of brick. In addition two bricks showing approximately the same resistance were selected from one set of a third brand. The modulus of elasticity, transverse strength, and thermal expansion of specimens cut from each of these brick were determined.

TABLE X

DETERMINATIONS AND CHECKS OF MODULI OF ELASTICITY AND RUPTURE OBTAINED ON COMMERCIAL AND LABORATORY PREPARED FIRECLAY BRICK

(After Firing 5 Hours at 1400°C)

Specimen	Modulus of elasticity (lbs./sq. in.)	Modulus of rupture (lbs./sq. in.)	Results obtained at
H*	365,000	310	Room temperature
	340,000	360	" "
L*	2,900,000	950	" "
	3,390,000	1040	" "
P*	1,849,000	920	" "
	2,050,000	990	" "
Q*	3,140,000	1125	" "
	3,280,000	1260	" "
Q—(SM)	3,400,000	950	" "
	3,480,000	1000	" "
C—(DP)	2,250,000	865	550°C
	1,900,000	790	"
E—(SM)	7,230,000	2530	"
	8,120,000	•	"
I—(HM)	4,175,000	1445	"
	4,010,000	1400	"
L—(DP)	2,530,000	995	"
	2,890,000	825	"
Q—(SM)	2,680,000	830	"
	2,720,000	855	"

* Commercially prepared fire brick.

(SM), (DP), and (HM) refer to stiff-mud, dry-press, and handmade methods of preparation of brick made in the laboratory.

• No data.

Curves showing the thermal-expansion behavior are given in Fig. 11. The curves plotted in the center and lower sections were obtained on brick showing a large difference in spalling resistance. The lower curve in each case represents the expansion behavior of the brick from one set showing the greater resistance to spalling. The expansion behavior of brick showing approximately the same resistance to spalling is illustrated by the curve in the upper section. The rate of expansion of the two bricks is practically identical.

Results of the other tests made on these specimens are as follows:

Brand letter	Number of quenchings to cause spalling	Modulus of elasticity (lbs./sq. in.)	Modulus of rupture (lbs./sq. in.)	Total thermal expansion at 1000°C (%)
D	3	3,360,000	420	0.567
D	45	2,318,000	300	0.540
E	5	1,530,000	1310	0.568
E	15	836,000	775	0.517
J	8	904,000	420	0.508
J	9	976,000	710	0.504

These data show that the large variations in spalling behavior of brick of the same brand are not altogether due to the method of testing for re-

sistance to spalling, but may be caused by large differences in the properties of the individual bricks. It will be noted that very little difference is shown in the modulus of elasticity and thermal expansion of the two bricks of Brand J, showing practically the same resistance to spalling whereas brick of Brands D and E show large differences in these properties and also show great differences in resistance to spalling. The brick of both Brands D and E having low resistance to thermal shock have the higher moduli of elasticity and higher thermal expansion.

The results obtained in these tests are not comparable with those tabulated in Table VIII since the tests were made on specimens using a 6-inch instead of an 8-inch span. The modulus of rupture decreased greatly after a brick has been subjected to the thermal-shock test, (compare results in the foregoing tabulation with those in Table VIII). Such a relation has also been found by Parmelee and Westman.[20]

(11) Relation between Resistance to Thermal Spalling and Modulus of Elasticity

If the various brands of brick are grouped into 2 classes, according to whether they withstood a greater or lesser number of quenchings than 15 in the spalling test and the averages of these groups

[20] "The Effect of Thermal Shock on the Transverse Strength of Fireclay Brick," *Jour. Amer. Ceram. Soc.*, **11** [12], 884–95 (1928).

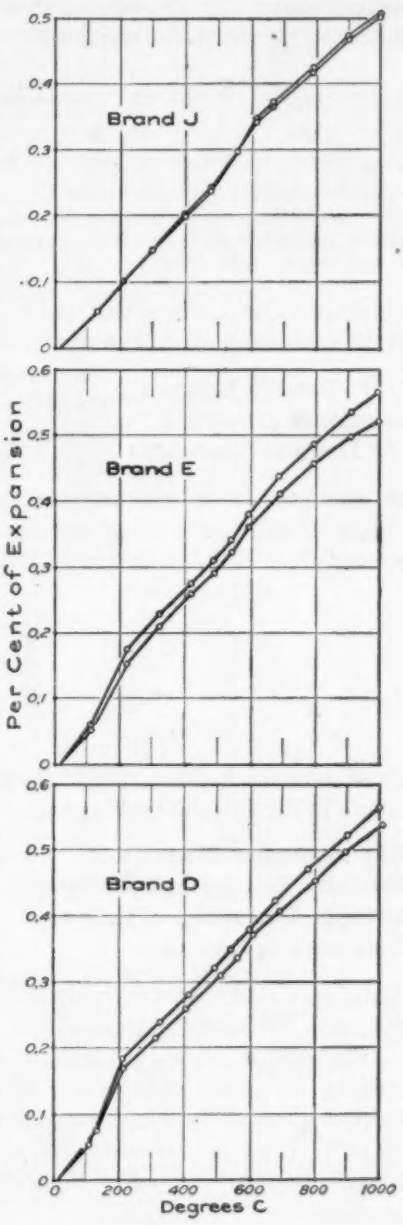

FIG. 11.—Curves showing expansion behavior of 2 bricks each of Brands D, E, and J.

are compared with the average moduli of elasticity of the same groups, the following results are obtained:

Number of brands*	Average number of quenchings to cause spalling	Average modulus of elasticity (lbs./sq. in.)
6	27	2,190,000
9	9	3,505,000

* Brands G and H are omitted from these averages because of their highly siliceous nature, and their early failure in the water-spalling test is in all probability due primarily to high thermal dilatation.

These averages indicate that the resistance of brick to spalling increases as the modulus of elasticity decreases.

(12) Relation between Resistance to Spalling and Thermal Expansion

The brands of brick were grouped into two classes, according to whether the total expansion per unit length, between 100°C and 200°C after firing at 1400°C as given in Table IV, was greater or less than 0.06%. The averages of these groups are compared with the average number of quenchings the groups withstood before failure in the spalling test. The results are as follows:

Number of brands	Average thermal expansion (%)	Average number of quenchings to produce spalling
9	0.039	22
8	0.102	8

These averages indicate that high thermal expansion is conducive to early failure in the thermal spalling test.

(13) Relation of Modulus of Elasticity, Expansion, Transverse Strength, Percentage of Grog to Resistance to Spalling

Some data have been presented by Norton,[21] and Booze and Phelps[22] indicating a possible relation between resistance of fire brick to spalling and the three factors (1) modulus of elasticity, (2) thermal expansion, and (3) rate of temperature change or diffusivity. An empirical relation, combining the three factors, (1) modulus of elasticity, (2) expansion, and (3) transverse strength, expressing the relative resistance, R, of saggers to failure due to thermal shock is given in the Third Progress Report of the Investigation of Sagger Clays.[23] It has been shown in the present report that a relation apparently exists between resistance of brick to spalling and elasticity and thermal expansion.

[21] *Jour. Amer. Ceram. Soc.*, **8** [1], 29–39 (1925).

[22] *Ibid.*, **8** [6], 361–82 (1925).

[23] See footnote 8.

The data also indicate that brick having an absorption below 5% and above 12% show less resistance to spalling than do those having absorptions within these limits.

The formula with which the resistance factor, R, may be computed has been changed to include a value for total grog present in the green brick batch. It is believed that this value gives some indication of the relative thermal conductivity of the materials. The formula at present reads as follows:

$$R = \frac{M \cdot G}{E \cdot e}$$

where R = factor indicating relative resistance of brick to spalling
M = modulus of rupture
G = grog expressed in parts of green batch materials (in per cent divided by 100)
E = modulus of elasticity
e = coefficient of expansion for the temperature range 20 to 250°C

TABLE XI

COMPUTED RESISTANCE FACTOR AND NUMBER OF QUENCHINGS REQUIRED TO CAUSE FAILURE OF FIRE BRICK

Laboratory key letter of brand	Resistance factor, R	Number of quenchings to cause failure
A	74	49
B	41	16
C	50	29
D	70	34
E	57	18
F	36	11
G	38	8
H	31	6
I	52	24
J	29	8
K	54	10
L	59	17
M	44	14
N	27	6
P	25	8
Q	83	49
R	19	8

The computed resistance values, R, are given in Table XI together with the number of quenchings required to cause failure. Figure 12 shows that the factor, R, is roughly proportional to the number of quenchings showing that the quantity $M \cdot G/E \cdot e$ is a fairly good indication of the resistance of a brick to spalling.

(14) Plastic Flow If the form of a body is found to be permanently altered when the stress exceeds a certain value, the body is said to be plastic for stresses in excess of this value.[24]

Typical load-deflection curves as obtained at 1000°C on a specimen cut from Brand K reheated at 1400°C are shown in Fig. 13. The upper curve

[24] Bur. Stand., *Sci. Paper*, No. 278.

shows the plastic flow of the material under various loads, the lower curve the total deformation under these same loads, and the middle curve the elastic properties.

The elastic recovery of the material was considered as the difference between the total deflection caused by the load and the "set" of the material on removal of this load.

The plastic flow of the various brands of brick is given in Table IX. The values given represent the flow of the material at a temperature of 1000°C at the end of one hour using a load of approximately 60 lbs. per sq. in., a specimen with a cross-section of approximately one inch, and an 8-inch span. The smallest deflection, 0.0001 inch, is shown by Brand N and the largest deflection, 0.0047 inch, by Brand J.

It is possible that certain of these values not only include the deflection associated with softening of the matrix but also may represent a partial

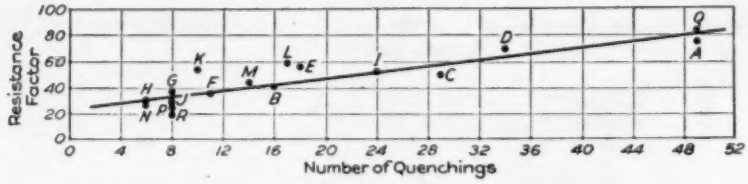

FIG. 12.—The computed resistance, R, of bricks to spalling plotted against the number of quenchings required to cause failure.

breaking down of the physical structure. No breaking down in structure, however, was evident in tests made with equivalent loads at room temperature.

V. Fireclay Brick Prepared in the Laboratory from Batch Materials Furnished by Manufacturers

(1) General Brick were made in the laboratory by dry-press, stiff-mud extruded (end cut), and handmade methods, from prepared batch materials furnished by fourteen manufacturers of fireclay refractories.[25] These brick were fired at 1400°C for five hours. In preparing these brick it was realized that (*a*) it would be impossible to duplicate firing conditions of industrial kilns in the laboratory kiln; (*b*) exact duplication of the physical structure of the laboratory prepared brick with that of the manufactured brick could not be expected, due to use of small scale laboratory apparatus; (*c*) the same batch materials as furnished by the manufacturers would rarely, if ever, be used in the manufacture of fire

[25] A description of the various methods of manufacture of fireclay brick may be found in Bur. Stand., *Circ.*, No. 282, "Fireclay Brick: Their Manufacture, Properties, Uses and Specifications."

brick in the three methods, though it is quite common practice to use the same batch composition for brick prepared by the dry-press and stiff-mud processes. It was believed, however, that information of value would be obtained from this study, not only to compare with test data of manufactured brick, but also to learn what effect a variation in the structure would have on certain physical properties.

A photomicrograph of a specimen cut from fired brick (Batch P), made by each of the three methods of manufacture, is shown in Fig. 14. This particular batch material[26] is used commercially for making a stiff-mud brick. The laminations in the stiff-mud brick are very pronounced and the structure of the handmade brick appears to be considerably more

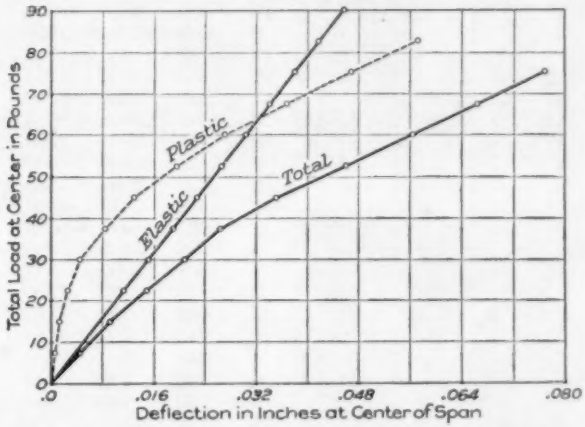

FIG. 13.—Load-deflection curves of fireclay brick, Brand *K*, at 1000°C. The total deflection, plastic flow or set and the elastic properties obtained with various stresses are shown.

dense. The brick made by the dry-press method shows the greatest uniformity.

The study of these brick included the determination of (*a*) resistance to spalling; (*b*) absorption; (*c*) modulus of elasticity and transverse strength at 20°C and at 550°C; (*d*) total linear fired shrinkage; and (*e*) linear thermal expansion from 20 to 1000°C.

(2) Tempering Water The "tempering" or "conditioning water," that is, the percentage of water considered as desirable for securing proper molding of the laboratory-prepared fire brick is given in Table XII. The loss in weight on heating a finished brick at 110°C for approximately 18 hours was considered as the water necessary for molding. It was found that the water required for molding brick

[26] There is very little difference in composition between this manufacturer's batch materials used for brick prepared by the stiff-mud and handmade processes.

from the various batch materials by (*a*) the dry-press method ranged from a low of 6.3% to a high of 13.7%; (*b*) stiff-mud extruded process ranged from 10.9 to 24.1%; and (*c*) handmade method ranged from 13 to 29.2%.

TABLE XII

DATA DETERMINED ON FIRECLAY BRICK, MADE IN THE LABORATORY FROM PREPARED BATCH MATERIALS FURNISHED BY THE MANUFACTURER

Laboratory key letter	Method of preparation[a]	Tempering water (%)	Linear fired shrinkage in % of wet length	Absorption in % of dry weight	Average number of quenchings to cause failure	Total expansion at 1000°C[b] (inch per inch)	Modulus of elasticity (lbs./sq. in.)[c] at		Modulus of rupture (lbs./sq. in.) at	
							20°C	550°C	20°C	550°C
A	DP	10.2	5.8	7.2	18	568	2230	2440	840	1340
A	HM	15.4	10.0	8.2	12	560	2860	3600	1085	1020
A	SM	16.4	10.1	7.7	9	566	2880	3960	1020	1110
B	DP	9.1	5.5	6.7	17	442	1640	1780	740	715
B	HM	12.4	8.4	9.0	19	448	3050	4280	1275	1550
B	SM	16.5	10.4	7.7	17	432	2230	3240	820	920
C	DP	6.4	3.5	9.3	18	442	2310	2075	985	830
C	HM	14.2	8.2	11.5	18	449	2740	2700	1015	1000
C	SM	13.0	8.4	9.4	9	470	1860	1800	680	620
D & N	DP	7.9	6.8	6.3	5	622	2000	3450	965	1370
D & N	HM	14.8	12.1	5.3	1	656	1810	7040	2400	1920
D & N	SM	17.1	13.2	4.4	2	627	4990	6030	2050	2400
E & F	DP	7.1	6.4	5.3	6	508	1990	3860	1140	1710
E & F	HM	16.1	13.6	4.9	3	607	5090		1290	
E & F	SM	19.7	14.2	2.9	2	570	4920	7230	2600	2530
G	DP	11.2	3.1	14.1	7	654	830	1260	450	690
G	HM	18.1	6.9	16.1	9	640	1500	1380	875	940
G	SM	22.0	8.2	15.3	8	643	1390	1680	755	1045
H	DP	11.8	2.0	14.4	6	746	240	340	365	360
H	HM	16.3	5.5	17.3	9	736	440		360	
H	SM	23.9	9.6	16.1	11	717	170	320	150	335
I	DP	7.6	5.1	6.7	20	529	1010	1660	620	780
I	HM	13.3	9.3	7.1	15	531	3110	4090	1265	1420
I	SM	15.4	10.0	7.1	28	526	1625	2200	810	975
J	DP	7.6	4.6	5.1	3	412	6430	6530	1590	1945
J	HM	16.1	10.0	4.9	3	412	5330	8100	1625	1590
J	SM	20.1	10.4	3.9	3	416	5300	6700	1670	1740
K & L	DP	8.0	5.7	7.1	16	475	2810	2710	1000	910
K & L	HM	12.3	8.4	7.6	13	484	5180	6270	1526	1635
K & L	SM	16.3	11.2	6.7	16	499	2550	2830	1028	1135
M	DP	6.3	3.3	8.0	6	419	3410	5050	1030	1500
M	HM	10.9	5.5	8.6	7	435	4910	3920	890	1075
M	SM	14.5	7.6	7.7	5	447	4530	4830	1335	1195
P	DP	13.1	3.9	14.6	2	622	550	740	390	545
P	HM	24.1	8.9	13.6	3	586	1420	1670	865	955
P	SM	29.2	12.4	13.9	3	610	1100	1320	485	620
Q	DP	10.7	10.4	4.8	24	445	2700	3390	955	1065
Q	HM	24.5	10.4	6.1	28	453	4880	5470	1270	1460
Q	SM	24.2	11.5	5.8	33	435	3440	2700	975	845
R	DP	13.7	5.3	10.9	7	595	1660	2280	840	930
R	HM	22.2	6.7	11.8	4	617	3030	3970	870	1325
R	SM	25.4	11.2	11.9	8	579	1960	2390	725	900

[a] DP, HM, SM refer to dry-press, handmade, stiff-mud, respectively.
[b] Values to be multiplied by 10^{-6}.
[c] Values to be multiplied by 10^{3}.

(3) Thermal Spalling Test

The results of the quenching test as conducted on a total of 42 different sets of five brick each are given in Table XII. These results show (1) the average number of quenchings required to cause failure to range from 1 to 33; (2) those brick (with one exception) with alumina content over 38%, have considerably greater resistance to spalling than those containing less than 38; (3) although some sets show little difference in spalling resistance between brick prepared by the different methods, others show almost 100% difference.

A photograph of brick prepared by the three methods from same raw batch material and subjected to thermal shock test is given in Fig. 15.

Figure 15 illustrates well the types of spalling considered representative of fireclay brick manufactured by the stiff-mud, handmade, and dry-press processes.

(4) Moduli of Elasticity and Rupture

The modulus of elasticity and transverse strength of specimens cut from the 42 different bricks were determined at 20°C and 550°C and are given in Table XII, with the exception of the results for the hand-made specimens, E and H, at 550°C.

FIG. 14A.

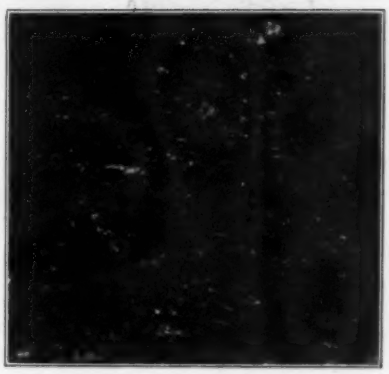

FIG. 14B.

FIG. 14C.

FIG. 14.—Photomicrograph (4.5 diameters) showing structure of brick made in the laboratory from manufacturer's green batch materials. Reading from left to right, the first is a section cut from a brick made by the stiff-mud method, the second dry-press, and the third, handmade.

There is a wide range in the values both at 20°C and at 550°C for elasticity and strength. The lowest value for modulus of elasticity obtained on specimen H (stiff-mud process) was 176,000 lbs./sq. in., and the lowest modulus of rupture, also obtained on this specimen was 150 lbs./sq. in., both values determined at approximately 20°C. The highest modulus of elasticity, found on specimen J (handmade process) at 550°C was 8,100,000 lbs./sq. in. and the highest modulus of rupture found on specimen E (stiff-mud process) at 20°C was 2600 lbs./sq. in. With few exceptions it was found that the material gave higher values for both modulus of elasticity and transverse strength at 550°C than at 20°C.

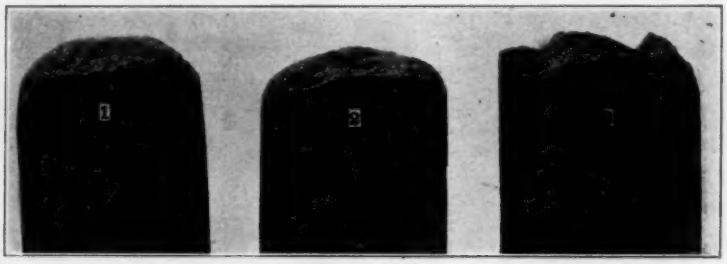

FIG. 15.—Types of failures of brick when subjected to the water-quenching test. The brick were made by the following method: (1) stiff-mud extracted; (2) handmade; (3) dry-press.

(5) Linear Fired Shrinkage The linear fired shrinkage in per cent of length when wet is included in Table XII with the other data determined on these brick. The range in shrinkage, for all the groups, is from 2.0 to 14.2%. The greatest range in shrinkage for any individual group representing specimens prepared from one batch composition by three different methods is from 6.4 to 14.2%.

(6) Linear Thermal Expansion No detailed data are presented on thermal expansion observations of laboratory-made brick since the curves obtained for these materials closely parallel those observed on the fire brick furnished by the manufacturers of the corresponding raw batch materials. A number of curves, however, are given in Fig. 16 to show either what effect the structure of the brick may have on this property or that the material from which the brick were made was nonhomogeneous, causing a variation in expansions as observed.

The lower graph in Fig. 16 shows the curves obtained on laboratory-made brick corresponding to Brand A. This is the only instance in which observations on brick made from the same batch material by the three different processes were identical throughout the entire range of tempera-

ture from 20 to 1000°C. This is especially noteworthy since the brick spalled in the quenching test after 9, 12, and 18 dips for the handmade, stiff-mud, and dry-press processed brick, respectively. In addition, the difference in absorption was only 1% and the inflection shown in the curve between 100°C and 200°C indicates that an appreciable quantity of quartz may have been converted to cristobalite.

The center graph of Fig. 16 shows the expansion curves obtained on laboratory-made brick corresponding to Brand E. These curves show the greatest difference in thermal expansion determinations on brick made from the same batch material by the three different processes.

The total expansion at 1000°C of the brick made by the handmade process is approximately 20% greater than the total expansion of the brick made by the dry-press method. An examination of the thermal expansion curves for these brick shows that a good portion of this difference in expansion is caused by the greater inflection of the curve at approximately 200°C for the handmade brick, possibly due to more of the quartz originally present having been converted to cristobalite.

The brick made by the dry-press method still shows quite an appreciable inflection between 550°C and 600°C.

Table XII gives the absorption of the brick made by the handmade process as 2.9%, and the brick made

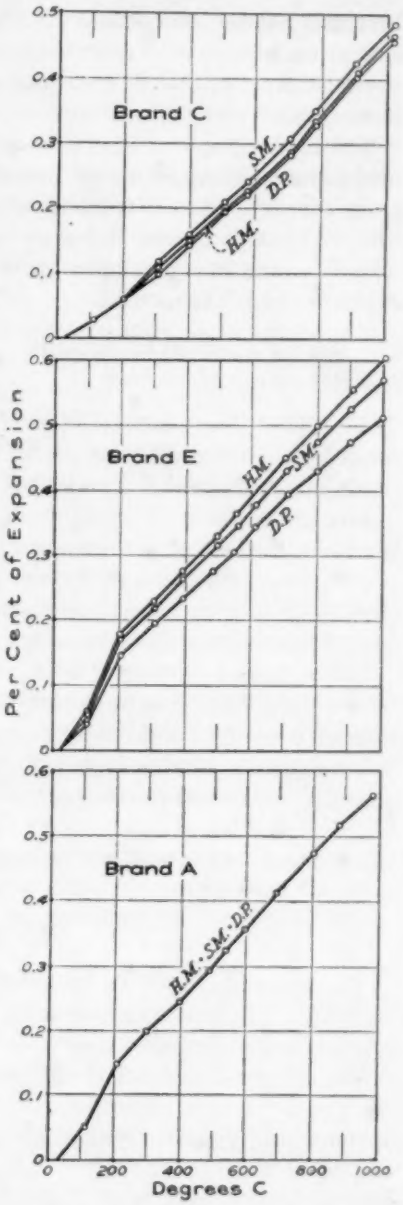

FIG. 16.—Curves showing linear thermal expansions of brick made in the laboratory by three methods, namely, stiff-mud extruded (SM); handmade (HM); and dry press (DP), from manufacturer's prepared "green batch."

by the dry-press process as 5.3%. This would possibly indicate that the conversion of quartz to cristobalite may be accelerated in the brick of the lower absorption, due to the probability of the fluxes being in more intimate contact with the quartz.

The upper graph in Fig. 16 shows the curves obtained on laboratory-made brick corresponding to Brand C. These curves are given to illustrate the difference in total expansion that may occur in brick having little or no free quartz and are molded by the three different methods. The difference in expansions may be due either to errors in sampling or to the structure of the material.

(7) Linear Thermal Expansion and Resistance to Spalling

The total observed linear thermal expansion at 1000°C for the 42 specimens of laboratory-made brick are given in Table XII. The greatest variation in the data for any one series of brick made by the three different methods occurs in those brick prepared from batch materials having a relatively large percentage of free or converted quartz present in a very finely divided condition. This may be expected since the method of preparation of the brick in these cases would have slightly more influence on the speed of reactions taking place during heating than in those brick having only a small percentage of free quartz or if the quartz is present in comparatively coarse grains.

Although in a number of cases there appears to be little or no relation between the total expansion and the resistance to spalling for any series of brick made by the three methods, there are a large number of instances where a definite relation is apparent between these two properties. Typical examples that show this relation are the brick identified by letters *G* and *H*. In a number of cases only two of the three sets in any one series show this relation. Groups E and M may be cited as examples.

VI. Summary

The materials furnished by manufacturers of refractories for this study include 17 different brands of fireclay brick, 14 green batches, 26 fire clays, and 3 samples of crushed quartz and silica sand.

The chemical analyses of the fire brick and fire clay are reported, and the results of such determinations as absorption, P.C.E. values, thermal spalling, and sieve analysis of grog used in green batch materials are recorded in a series of tables. The thermal expansions of the fire clays fired at 1400°C and those of the fire brick "as received" from the manufacturer and after reheating in the laboratory kilns at 1400°C, 1500°C, and 1600°C are given and the materials are classified into groups according to the type of expansion. In addition, the modulus of elasticity and transverse breaking strength of the brick have been determined not only

at several temperatures but also after the brick had received several different heat treatments.

These data show that the thermal expansions of the majority of brick decrease as the temperature of firing is increased. This would lead to the conclusion that interstructural stresses which may be caused by differences in the thermal expansions initially present between materials entering into the manufacture of a brick, are gradually reduced.

Data are presented which indicate that the thermal expansion of the finished brick may not necessarily be the average of the expansions of the clays entering into its composition.

The moduli of elasticity of the brick were generally much greater when tested at 550°C than when tested at 20°C. At 1000°C, the modulus of elasticity was less than results obtained at either 20°C or 550°C, *i.e.*, the brick became less rigid and more subject to plastic deformation. The modulus of elasticity and transverse strength increase as the temperature of firing of the brick is increased. The increasing percentage of glass formed would cause this behavior.

Resistance of fire brick to spalling on an average decreased with increase of modulus of elasticity and increase of thermal expansion.

Data are given to show that sufficient differences exist in the physical properties of brick of the same brand to cause large variations in the number of quenchings required to cause spalling.

Brick were made in the laboratory by the dry-press, stiff-mud extruded, and handmade methods from manufacturer's green batch materials. Test results indicated no apparent relation between method of preparation of brick and their thermal expansion, but there is direct relation between expansion and resistance to spalling.

An empirical relation is given which expresses the resistance of fireclay brick to spalling as varying directly as the modulus of rupture and grog content and inversely as the modulus of elasticity and coefficient of expansion.

THE EFFECT OF VARIOUS ADDITION AGENTS AND TREATMENTS ON THE GREEN STRENGTH OF MISSOURI REFRACTORY CLAYS[1]

By A. J. Paul[2] and M. E. Holmes[3]

ABSTRACT

Tests were made with the plastic and semiflint fire clays of north central Missouri and the burley diaspore of south central Missouri. Aging plastic fire clay ten days produces about a 38% increase in modulus of rupture. Na_2CO_3 treatment produces about a 50% increase. Tannic acid which flocculates the colloids improved the modulus a good deal; an acid treatment after an alkali treatment, however, produced no added effect of importance. The effect of developing bacterial growth was marked, especially if aged for a considerable time. Grape juice had a specific effect. The addition of bentonite Collotone R increased the modulus almost 3 times. The maximum is reached with about 8% bentonite. The additive effect of dextrine in combination with bentonite is positive but of negligible consequence. Tennessee ball clay is without important positive effect in amounts up to 8%.

Sodium silicate additions up to 8% gave negative results.

With as little as 4% bentonite the modulus of rupture of flint clay is tripled. Aging of flint clay has an important positive effect. Effect of the bentonite can be obtained in the dry-press, stiff-mud, or soft-mud bodies, but it is greatest in the stiff-mud.

Burley clay is less self-bonding than the flint and the effect of the bentonite was more marked even than in the case of flint. Four per cent bentonite increased the modulus of rupture to about $4\frac{1}{2}$ times its original modulus of rupture.

The modulus of rupture of flintclay-bentonite mixtures might approach that of plastic fireclay-bentonite mixtures at high contents of bentonite, leading to the indication that in the case of these two clays the total colloidal content is the determining factor.

With 3% bentonite the modulus of rupture of the flint is made equal to that of the plastic and straight, a result applicable to problems where the dissolving out of the bonding material in the refractory is a determining factor in service. The P.C.E. of the plastic fire clay drops 1 cone for 3% and 2 cones for 6% of bentonite addition.

Introduction

In some cases refractory clays are weathered for the purpose of preparing them for the purification operations and for improving their workability and bonding properties. In the manufacture of glass pots, the weathering of the plastic fire clay is an important consideration. D. H. Fuller[4] states that in the manufacture of glasshouse refractories the bond clay must possess good plasticity and bonding power. Otto Bartsch[5] points out that glass pot bodies are stronger in the green state than other ceramic bodies, and referring particularly to Gross Almerode clay he states that its strength of 37 kg. per sq. cm. is increased 10 to 27% by weathering.

[1] Presented at the Annual Meeting, American Ceramic Society, Chicago, Ill., February, 1929. (Refractories Division.)

[2] Ceramic Engineer, Missouri Clay Testing and Research Laboratories.

[3] Prof., Ceramic Engineering, Missouri School of Mines and Metallurgy.

[4] "A Study of Some Bond Clays," *Jour. Amer. Ceram. Soc.*, **4**, 903 (1921).

[5] "Strength of Unfired Ceramic Ware," *Keram. Rundschau*, **35**, 121 (1927).

He further states that the weathering may be prolonged to the extent of reducing the strength. Bartsch attributes the increase in strength in this case to colloidal silica. A. V. Bleininger,[6] referring to bond clays for glass pots, states that when mixed with equal weights of sand, they should show a modulus of rupture of 277 pounds per square inch.

Although weathering of the clay is a less important matter in manufacturing fire brick than it is in glass pot manufacture, yet it is sometimes employed. The manufacture of refractory ware out of hard flint clays is difficult without weathering or without the addition of a plastic bonding clay. The same statement applies to burley and diaspore, although in less degree because they contain considerable amounts of plastic material.

Depending upon the character of the clay and the weathering conditions, chemical and physical changes, in various degrees, are produced by weathering. The ferrous minerals may be oxidized; the soluble salts may be leached out and certain physical changes in the clay produced. Months or years are involved in the weathering operation. This investigation is concerned solely with the physical effects of weathering, and more particularly the purpose of the investigation may be stated as a study of the means of immediately producing physical effects equivalent to those produced by the time-consuming weathering operations.

The physical effects of weathering are numerous, but in general the most important effects are those that have to do with plasticity, workability and bonding power. Included in the essential requirements for a satisfactory degree of plasticity, workability, and bonding power are (1) a uniform and complete distribution of the tempering water through the body, (2) a content of colloidal clay of sufficient degree, and (3) a gel condition of the colloidal clay. Workers on other materials and related problems have recognized these principles. H. W. Douda[7] has studied the effect of electrolytes and certain physical treatments on the dry strength of clay. H. G. Schurecht and H. W. Douda[8] show that a small addition of bentonite increases the dry strength of clays. They conclude "It may be possible to make synthetic glass pot clay approaching the Arkansas clays in properties by adding quartz and small amounts of bentonite to fire clay." It is general practice to add ball clay or other plastic clay to bodies deficient in plasticity.

Outline of the Investigation

Improved plasticity, workability, and bonding power were studied by means of:

[6] Bur. Stand., *Tech. Paper*, No. 144.

[7] "The Effect of Wet Grinding, Screening, Electrolytes and Dextrine on Clays of Low Plasticity," *Jour. Amer. Ceram. Soc.*, **3**, 875 (1920).

[8] "The Properties of Some Claylike Materials of the Bentonite Type," *Jour. Amer. Ceram. Soc.*, **6**, 940 (1923).

(1) Uniformly and effectively distributing the tempering water by subjecting the clay to steam treatment under pressure.
(2) The increase in the colloid content of the body by
  (*a*) Adding a plastic clay such as ball clay.
  (*b*) Adding a highly colloidal material such as bentonite.
  (*c*) Deflocculating the clay with alkali salts.
(3) Converting the colloid sols into gels.
(4) The addition of an organic colloidal bonding material.
(5) The development of bacterial growth.

The steam treatment of the clay was done with a laboratory autoclave at a pressure of 450 lbs. per sq. in. and a temperature of 480° for 2 hours. In one case the clay was introduced into the autoclave dry and in the other case, in a plastic condition.

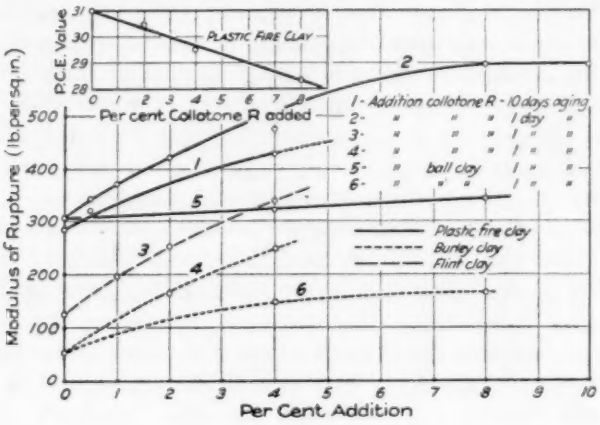
P.C.E. Value
PLASTIC FIRE CLAY
Per cent Collotone R added
1 - Addition collotone R - 10 days aging
2- " " " 1 day "
3- " " " 1 " "
4- " " " 1 " "
5- " ball clay 1 " "
6- " " " 1 " "
Modulus of Rupture (lb. per sq. in.)
Plastic fire clay
Burley clay
Flint clay
Per Cent Addition

FIG. 1.

The development of organic growth was effected with grape juice. Dextrine was the organic bonding material added. As a means of increasing the colloid content to a moderate degree and a high degree ball clay and bentonite, respectively, were used.

Tests

Many suggestions have been made on special tests for the various physical properties which are involved in this investigation. There has been no general agreement, but we believe that the transverse green strength, as indicated by the modulus of rupture determination, is the most practicable and useful for our purpose. The investigation may, therefore, be described as a determination of the various treatments upon the green strength of Missouri flint, burley, and plastic clay. Tests of secondary importance include the standard P.C.E. value determination,

linear and volume shrinkage, and per cent water of plasticity. All values of modulus of rupture varying 15% from the average were discarded and new averages calculated until all values were within the 15% maximum variation from the average.

Experimental Procedure

The clay was properly quartered and ground to pass a 20-mesh sieve. (The clay used for each series was ground at different times, so that a screen analysis is reported for the clay used in each series. Since all mixes in any one series are made of the same clay any mix is comparable to any other in that series.)

The addition of soluble salts was made by dissolving them in the water used to temper the clay. The acid was added after the sodium carbonate had a chance to act upon the clay. The addition of grape juice was made direct by using it in place of the water required to temper it. The ball clay and bentonite (Gelacol and Collotone R) were introduced by mixing them dry with the clay and then tempering the mixture.

After incorporating the addition agents each lot was tempered to maximum plasticity, as indicated by the feel. The clay was then aged for one and ten days, respectively, as indicated in the tables, and molded into 1 - x 1 - x 6-inch bars. The bars were marked for linear shrinkage determinations. One of the 6-inch bars was cut into three smaller bars used for water of plasticity and volume shrinkage determinations. All bars were dried according to standard AMERICAN CERAMIC SOCIETY procedure.

Discussion of Plastic Fireclay Results

Series I Results Whereas the ordinary weathering of the plastic fire clay for two months produced only a 10% increase in modulus of rupture, the treatment with a strong deflocculating agent, sodium carbonate (lot B), produced a 50% increase immediately. The theoretically less effective sodium chloride produced only a 15% increase. Following up the deflocculating action of sodium carbonate by the coagulating action of an acid, added in sufficient quantity to cause the reaction to pass the neutral point (lot E), gave a negative result in that no further improvement was obtained. The result is not easy to explain in view of the fact that the direct acidification of the clay, tannic acid lot D, produced a positive effect.

Lot H, which contains a small amount of extremely fine ground clay is a noteworthy exception to the general tendency for 10 days aging of the tempered mix to produce considerable improvement in strength. This indicates a slaking effect in addition to the effect of uniform and complete moisture distribution.

TABLE I

SERIES I: EXPERIMENTS WITH PLASTIC FIRE CLAY

Mix	Addition (%)	Aging time (days)	Water of plasticity (%)	Drying shrinkage %		Modulus of rupture (lbs./sq. in.)	Change of modulus of rupture
				Linear	Volumes		
*A	No (original)	1	18.6	5.7	17.2	238	
A-1	No	10	18.2	5.6	16.7	329	38.2
B	0.5% sodium carbonate	1	18.3	5.1	15.2	356	49.7
B-1	" " "	10	19.3	5.8	18.9	403	69.4
C	0.5% NaCl	1	18.7	4.7	15.5	273	14.7
C-1	" "	10	19.7	5.9	15.7	334	40.3
D	0.5% tannic acid	1	19.6	5.3	14.8	356	49.7
D-1	" " "	10	19.6	6.3	16.4	411	72.7
E	0.5% Na_2CO_3 then treated with HCl	1		6.9		316	32.8
E-1	Same as E	10		6.3		348	46.3
F	0.5% $AlCl_3 \cdot 6H_2O$	1	19.1	5.9	18.3	203	−14.7
F-1	" "	10	19.7	5.5	17.3	254	6.7
G	0.5% dextrine	1	18.7	5.3	17.2	449	88.7
G-1	" "	10	18.7	5.9	18.8	449	88.7
H	10% 200-mesh clay added	1	19.1	5.4	17.5	314	31.9
H-1	Same as H	10	19.2	6.0	16.5	318	33.6
I	Same as H + 0.5% Na_2CO_3 then treated with HCl	1		6.7		321	34.8
I-1	Same as I	10		8.0		356	49.7
J	Tempered with grape-juice	30	19.8	5.7	19.2	354	34.8
J-1	Same as J	180	18.9	5.3	16.4	466	96.0
K	Weathered 2 months	1	20.2	5.5	18.9	262	10.0
K-1	" " "	10	20.2	6.2	20.9	356	49.7
2G	11% Collotone R	1				645	170.0

Series I (mesh)	Clay-screen analysis (%)
20–40	40.0
40–100	46.8
100–200	8.8
Through 200	4.3

* The basis for figuring the per cent change of modulus of rupture is made on the original Mix A in this series of experiments.

The indications are that the growth of bacteria such as is fostered by the addition of grape juice, produces a marked increase in strength but that it is such a slow process that it falls outside of the objective of this investigation.

The results obtained with dextrine and bentonite, particularly the latter were of such magnitude as to challenge further attention. With 11% bentonite a 170% increase in strength was obtained. With 5% dextrine the strength was increased more than two-thirds.

Second Series The second experiment of this investigation was conducted to yield more detailed information on the use of dextrine and bentonite, particularly in regard to the matter of varying the amount of these addition agents and combination of them. The same clay was used as in the first experiment but the fineness is slightly different, a

condition which requires caution in case a comparison is desired between the results of any lot in Experiment I with any lot in Experiment II. All lots of Experiment II are, of course, strictly comparable with each other.

The outline of this experiment and the results obtained are given in Table II.

TABLE II

SERIES II: EXPERIMENTS WITH PLASTIC FIRE CLAY

Mix	Addition (%)	Aging time (days)	Drying shrinkage (%) Linear	Drying shrinkage (%) Volume	Water of plasticity (%)	Modulus of rupture (lbs./sq. in.)	Change of modulus of rupture (%)
*L	No (original)	1	5.8	17.6	18.5	306	
L-1	No	10	5.3	14.5	17.4	285	−6.9
M	0.25% dextrine	1	6.3	18.1	18.0	356	16.3
M-1	" "	10	5.1	16.0	17.7	383	25.1
N	0.50% Collotone R	1	6.3	17.3	18.3	344	12.4
N-1	" "	10	5.3	15.9	17.8	321	4.9
O	0.25 dextrine + 0.50 Collotone R	1	6.3	18.8	18.8	379	23.8
O-1	Same as O	10	5.8	16.9	18.3	386	26.1
P	1.0 Collotone R	1	6.0	16.1	18.4	370	20.9
Q	2.0 " "	1	6.0	16.9	18.5	427	39.5
R	4.0 " "	1	6.5	19.7	19.5	475	55.3
R-1	4.0 " "	10	6.4	17.2	19.0	437	42.8
S	0.25 dextrine + 4.0 Collotone R	1	6.7	21.1	20.0	520	70.0
S-1	Same as S	10	6.5	19.3	19.8	483	57.8
T	8.0 Collotone R	1	7.6	22.0	21.3	598	95.7
U	10.0 " "	1	7.8	22.7	22.0	597	95.3

Series II (mesh)	Clay-screen analysis (%)
20–40	35.5
40–100	32.7
100–200	20.6
Through 200	11.2

* The basis for figuring the per cent change of modulus of rupture is made on the original Mix L in this series of experiments.

TABLE III

P.C.E. VALUES ON PLASTIC FIRE CLAY AND COLLOTONE R MIXES

Mix	Collotone R (%)	Plastic fire clay (%)	P.C.E. value
L	0	100	31
Q	2	98	30–31
R	4	96	29–30
T	8	92	28+

Results of Series II and III

It is shown that 0.5% bentonite has a positive effect on the strength of the body, and increasing the amount of bentonite up to 8% produces a continuous increase in strength where a maximum effect is obtained. The ten days aging of the tempered mix produces no increase in strength in the case of the lots containing bentonite.

TABLE IV

SERIES III: EXPERIMENTS WITH PLASTIC FIRE CLAY

Mix	Treatment or addition (%)	Aging time (days)	Drying shrinkage (%) Linear	Drying shrinkage (%) Volume	Water of plasticity (%)	Modulus of rupture (lb./sq. in.)	Change of modulus of rupture (%)
*W	No (original)	1	6.4	18.3	19.2	278	
†V	Steam treated (clay in plastic state)	1	5.7	16.9	18.9	241	−13.3
†V-1	Steam treated (clay in dry state)	1	4.2	12.0	16.0	183	−34.1
X	1 Tenn. ball clay	1	6.1	18.6	19.3	258	− 7.2
Y	2 Tenn. ball clay	1	6.2	18.0	19.4	296	6.5
Z	8 Tenn. ball clay	1	6.0	17.7	19.45	208	−25.1
W-D	2.0 dextrine	1	6.0	19.7	18.5	444	59.8

Series III (mesh)	Clay-screen analysis (%)
20–40	41.35
40–100	33.35
100–200	16.15
Through 200	8.90

* The basis for figuring the per cent change of modulus of rupture is made on the original Mix W in this series of experiments.

† Mixes V and V-1 were subjected to a temperature of 480°F and a steam pressure of 450 lbs./sq. in. for 2 hours.

TABLE V

SERIES IV: EXPERIMENTS WITH PLASTIC FIRE CLAY

Mix	Addition (%)	Aging time (days)	Water of plasticity (%)	Drying shrinkage (%) Linear	Drying shrinkage (%) Volume	Modulus of rupture (lb./sq. in.)	Change of modulus of rupture (%)
*AA	No (original)	1	18.0	5.5	15.8	311	
AA-1	No (original)	10	18.0	5.7	14.5	286	−8.2
BB	0.05 sodium silicate	1	17.7	4.8	13.4	387	24.4
BB-1	" " "	10	17.3	4.4	13.2	263	−15.4
CC-1	0.10 " "	10	18.4	5.7	14.7	339	9.0
DD-1	0.20 " "	10	18.3	5.9	13.8	224	−28.0
EE	0.40 " "	1	18.8	5.3	14.2	298	− 4.2
EE-1	0.40 " "	10	17.3	4.8	12.7	209	−32.8
FF-1	0.80 " "	10	18.7	5.3	13.1	252	−18.9
GG-1	0.25 Gelacol	10	18.0	5.5		301	− 3.2
HH-1	0.50 "	10	18.4		14.0	265	−14.7
JJ-1	1.00 "	10	17.5	5.7	13.8	403	29.6
KK	2.00 "	1	17.1	5.5	13.7	524	70.1
KK-1	2.00 "	10	18.0	5.5	15.3	390	25.4
LL-1	4.00 "	10	19.7	7.5	20.4	542	74.3
RR-1	4 Collotone R washed and filtered	10	19.2	7.1	18.7	501	61.0
SS-1	4 Collotone R	10	20.2	7.1	19.6	515	65.6
A1A	4 Hercules ball clay	1	17.8	5.7	16.0	323	3.9
A2A	8 " " "	1	18.5	5.5	16.5	345	10.9

Series IV (mesh)	Clay-screen analysis (%)
On 20	0.1
20–40	33.1
40–100	32.6
100–200	14.9
Through 200	19.1

* The basis for figuring the per cent change of modulus of rupture is made on the original Mix AA in the Series IV experiments.

The effect of mixtures of dextrine and bentonite seem to some extent to be additive. Addition of 0.25% and 0.5% bentonite produces a 25% increase in green strength.

Four per cent of Collotone R bentonite produces a 1-cone drop in P.C.E. and 8% produces a 3-cone drop. No investigation was made with various brands of bentonite or with different kinds of clays in regard to P.C.E. value. Considerable variation with the various materials would be expected.

The steam produced no increase in strength. This indicated that the matter of a complete and uniform distribution of the tempering water is at most a minor effect as compared with the effect of adding a highly colloidal material.

TABLE VI

SERIES V: EXPERIMENTS WITH FLINT CLAY

Mix	Addition or treatment	Aging time (days)	Water of plasticity (%)	Drying shrinkage (%)		Modulus of rupture (lb./sq. in.)	Change of modulus of rupture (%)
				Linear	Volume		
*MM	No (original)	1	16.6	3.5	9.7	126	
MM-1	" "	10	16.1	3.1	8.7	125	0.8
NN	1% Collotone R	1	17.8	3.9	10.7	196	55.6
OO	2% " "	1	17.7	4.1	10.4	251	99.3
PP	4% " "	1	18.6	4.6	12.4	328	168.8
PP-1	4% " "	10	18.6	4.3	12.3	385	205.3
M1M	No, dry press	1	8.3	0.4		50	
M2M	No, stiff mud	1	18.4	4.0		117	
M3M	No, soft mud	1	22.7	5.5		77	
P1P	4% Gelacol, dry press	1	9.4	0.7		137	
P2P	4% " , stiff mud	1	17.5	4.2		346	
P3P	4% " , soft mud	1	24.3	5.4		268	

Screen analysis of flint clay

(mesh)	(%)
20–40	41.0
40–100	38.4
100–200	15.4
Through 200	4.8

* The basis for figuring the change of modulus of rupture in Series V experiments is made on the original Mix MM.

The results with the relatively high percentage of dextrine were about the same as obtained with a comparatively small amount, indicating that the maximum effect of this material is obtained with a fraction of a per cent.

The Tennessee ball clay produced no increase in strength even when used to the amount of 8%.

Discussion of Series IV

The data for "Gelacol" bentonite are very similar to that obtained for Collotone R in the second experiment. The bentonites are practically equivalent in increasing the green strength of plastic fire clay. Furthermore, neither showed any increase in strength on ten days aging of the tempered mix.

The Hercules ball clay proved to be quite superior to the Tennessee ball clay, but of negligible consequence compared with either of the two bentonites.

Sodium silicate in any amount from 0.05% up to 0.8% failed to produce a positive effect. It is difficult to explain this result, in view of the fact that sodium silicate is understood to be very effective as a deflocculating agent.

The following results apply to burley and flint clays in stiff-mud, dry-press, and soft-mud bodies.

TABLE VII

SERIES VI: EXPERIMENTS WITH BURLEY CLAY

Mix	Addition	Aging time (days)	Water of plasticity (%)	Drying shrinkage (%)		Modulus of rupture (lbs./sq. in.)	Change* of modulus of rupture (%)
				Linear	Volume		
*TT	No (original)	1	19.6	4.2	8.6	52	
UU	2% Collotone R	1	21.1	5.5	12.8	162	212
VV	4% " "	1	21.7	5.8	14.2	247	375
B1B	4% Hercules Ball clay	1	21.0	4.4	12.3	148	185
B2B	8% " " "	1	21.8	5.0	13.4	162	212

Screen analysis of burley clay

(mesh)	(%)
20–40	40.8
40–80	28.5
80–150	14.7
150–200	10.2
Through 200	5.4

* The basis for figuring the per cent of change of modulus of rupture in Series VI experiments is made on the original Batch TT.

Effect of Bentonite and Hercules Ball Clay on Flint and Burley Clays

Discussion of Series V

As in the case of the plastic fire clay, bentonite increased the strength of flint clay in marked degree. As would be expected from the properties of the two materials, the effect on the flint clay bodies was much greater than on the plastic clay bodies. With 4% Collotone R bentonite, an increase in strength of 205% was obtained. This required a ten-day aging of the mix, which brings out the point that in the case of flint clay, aging of the clay-bentonite mixture increases the effect of the bentonite, whereas, in the case of the plastic fire clay it does not.

By the addition of $3^1/_2$% bentonite the green strength of flint clay is made equal to that of plastic clay straight.

Bentonite is about equally effective in increasing the strength of flint clay whether used in dry-press, stiff-mud, or soft-mud bodies. Stiff-mud bodies developed the greatest strength, followed in order by the soft-mud and dry-press bodies.

Discussion of Series VI

As in the case of plastic and flint clay, the effect of bentonite was decidedly positive. A 325% increase in green strength was secured by the addition of 4% bentonite to burley clay. Manifestly the bonding material naturally occurring in this burley clay is quite ineffective. It may be noted further that of the three clays used the one with the highest intrinsic strength responded the least to the bentonite additions, and the one of lowest intrinsic strength responded the most to bentonite additions.

Another contrast with the results obtained with plastic fire clay, is that in the case of burley clay the addition of Hercules ball clay increased the strength in marked degree. The probabilities are that in the case of flint clay, a result intermediate in value between that on plastic and burley clay would have been obtained.

Conclusion

Bentonites, of the character of Gelacol and Collotone R, in small amounts, will produce a very substantial increase in green strength of bodies made from them.

This increase is greatest for burley clay, least for plastic fire clay, and of intermediate value for flint clay.

The maximum increase obtained with 4% of bentonite was 375%.

The effect of the bentonite on a percentage basis is about the same in dry-press, stiff-mud, and soft-mud bodies. Stiff-mud bodies gave the highest strength and dry-press bodies the lowest strength.

In the case of a material of low plasticity such as burley clay, a highly colloidal clay, such as Hercules, will, when added in amounts as small as 4%, produce increases in green strength as high as 185%. With a moderately plastic material, such as plastic fire clay, the effect is quite small.

The treatment of plastic fire clay with steam under pressure offers no encouragement; neither does the treatment of plastic fire clay with sodium silicate.

The deflocculating action of sodium carbonate is evidently moderately effective, as indicated by a green strength increase of 70%. Likewise flocculation with certain acid, particularly tannic acid, is moderately effective, as indicated with a 70% increase in strength with the use of 0.5% of this material.

Organic growth, such as is induced by grape juice, has a marked positive effect on the strength of the body, but many months are required for its effect to approach the results obtained immediately with bentonite.

Negative results or results of negligible consequence were obtained with salt and aluminium chloride. A small addition of dextrine produced positive results of considerable magnitude. The effect did not increase with additions of more than 0.5%.

On account of fluxing action the use of bentonite in amounts larger than 2% is precluded in ware that must have a maximum possible P.C.E. value. Within the limits of this investigation the drop in P.C.E. value is approximately 1 cone per 3% addition of Collotone R.

Of all the treatments and addition agents used, the ones that gave the most promising results are the ones that are believed to have increased the colloid content the greatest. This serves to emphasize the importance of colloid chemistry in clay technology and lends support to the theory that green strength, as well as the correlated properties of plasticity, workability, and bonding power, are controlled in large measure by the amount and character of colloidal matter.

Insofar as green strength itself and the other properties indicated by green strength are concerned, it is evident that with the use of a small percentage of bentonite, the results obtained by weathering can be duplicated and exceeded and the long weathering operation avoided. Other effects of weathering have not been studied in this investigation.

GEOLOGIC RELATIONS OF THE DIASPORE AND FLINT FIRE CLAYS OF MISSOURI[1]

By H. S. McQueen[2]

ABSTRACT

Sink-hole type deposits filled with flint fire clay have been known in the Ozark region of Missouri for many years. Within the last ten years, an associated clay, formerly discarded as waste, but now recognized as diaspore clay has been developed. The paper outlines the general geology of the district and discusses the clays and mode of occurrence of the deposits. Brief mention is made regarding future production and probable developments in this interesting district.

Introduction

The discovery of high alumina or diaspore clay associated with flint fire clay in the north-central Ozark region of Missouri has been the outstanding feature in the development of the state's ceramic resources, and perhaps the most important contribution to the refractories industry of the nation during the last decade.

The occurrence of flint fire clay filling sandstone-lined sink-hole type deposits[3] had been known since 1872,[4] when the first deposit was found as a result of prospecting for iron ore near Rolla, Phelps County. As the flint fire clays were developed, attention was drawn to an associated material, which had a rough sandy texture, and was known as "sand" or "sandy clay." It was discarded as waste, as its very appearance mitigated against using it as a material in the manufacture of fire brick.

Some knowledge of the high alumina content of the material had been obtained by 1908,[5] and by 1914[5] high alumina refractories had been manufactured. The first commercial shipments were probably made in 1918 by the late W. S. Cox of Cuba, Mo., and the rapid development of this clay is attested by the statistics of production for 1927[6] which show a total production of 40,085 tons, valued at $229,095.

The producing district is restricted to areas in the north central Ozark region, which are underlain by rocks of Pennsylvanian age. This series has been used in the preparation of a map[7] of the district, and as outlined (see Fig. 1) underlies approximately 600 square miles.

[1] Presented at the Annual Meeting, American Ceramic Society, Chicago, Ill., February, 1929. (Refractories Division.) Published by permission of the Director of the Missouri Bureau of Geology and Mines.

[2] Assistant State Geologist.

[3] H. A. Wheeler, "Clay Deposits," *Mo. Geol. Surv.*, **12**, 202 (1896).

[4] *Ibid.*, p. 233.

[5] J. L. Crawford, "High Alumina Refractories," *Jour. Amer. Ceram. Soc.*, **6** [1], 291 (1923).

[6] The statistics were collected by the U. S. Bur. of Mines in coöperation with the Mo. Bur. of Geol. and Mines.

[7] "Map of East-Central Missouri Fire Clay Districts," Mo. Bur. of Geol. and Mines, 1926.

Flint fire clay has been found elsewhere in Missouri, but the diaspore clay appears to be restricted to this area, as well as the United States as a whole, as no deposits, comparable commercially, are known elsewhere.

The district is a part of a moderately dissected northward-sloping plateau. In the areas underlain by the clay-bearing Pennsylvanian series, it is characterized by broad flat uplands and divides, which represent in part, the surface of the former plateau. Subsequent erosion has considerably dissected the surface, however, and the major streams of the district have cut deeply into the underlying rocks and as a whole, the features presented are those of a rugged type of topography, characteristic of the Ozark region of Missouri.

The deposits bear some relation to the topography in that they occur in the upland areas or around the margins. The "breaks" have been of particular interest to the prospector, and many deposits have been found from some surface expression produced by erosion.

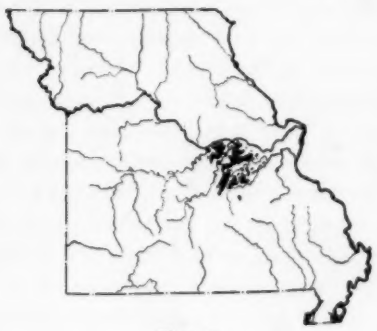

FIG. 1.

The clays apparently filled the sinkhole structures prior to the formation of the peneplain now reflected by the even-topped sky line characteristic of this part of Missouri and also before the subsequent tilting of this nearly level surface to the north. In the southern part of the field, deposits are found at an elevation of over 1100 feet; in the extreme northern part, elevations of 750 feet are common, and intermediate elevations are found in intervening parts of the field.

The area is not completely covered by topographic maps, but those available show at a glance the upland surfaces in which the deposits are generally found. These maps can be used effectively in prospecting.

Stratigraphy The rocks exposed range from Cambrian to Lower Pennsylvanian in age. The section is not complete, however, and numerous breaks of considerable importance are recorded in the geologic column.

The formations exposed may be summarized as follows:

Cambro-Ozarkian Rocks In the southern part of Crawford County, flint fireclay deposits are found in an area of considerable structural complexity. Within this area some of the oldest sedimentary rocks in the geologic column of Missouri are exposed. The Cambro-Ozarkian rocks are chiefly cherty dolomites, shale, and sandstone, the latter marking the base of the sedimentaries and resting

upon the pre-Cambrian granite. The thickness of this series is at least 1000 feet or possibly more.

Ordovician Rocks The Gasconade formation marks the base of the Ordovician rocks in Missouri. It consists of a series of cherty dolomites, and often a basal sand, the total thickness being 250 to 300 feet. It is exposed in high bluffs along the major streams and tributaries of the area under discussion, where the typical leaden color of the weathered rocks is a conspicuous feature. As will be pointed out later, this formation, as it affects the clay deposits, is thought to be of considerable importance.

Overlying the Gasconade dolomites are interbedded sandstones and cherty dolomites comprising the Roubidoux formation. This formation is exposed around the eastern, southern, and western margins of the clay-producing area, and in a narrow belt along one of the major fault zones extending from north to south through the central part of the field. The sandstones of this formation are sometimes mistaken for the sandstones intimately associated with the clay deposits. They have certain distinguishing characteristics, however, and among them may be mentioned cross-bedding, ripple-marks, and more distinct bedding planes. The sandstones at the base of this formation are important in that they form the wall rock around sink-hole type deposits of red hematite or iron ore, in the same way that the Pennsylvanian sandstones form the wall rock around the clay deposits under discussion.

The magnesian limestones and thin local sandstones of the Jefferson City formation overlie the Roubidoux, and in general separate it from the Pennsylvanian rocks. Its distribution within the diaspore-flint fireclay area is extensive, and it forms the country rock in the vicinity of a large number of clay deposits. The formation has certain distinguishing features, notably, beds of light-colored earthy magnesian limestones and more crystalline beds of dolomite, which weather into a characteristic pitted rock. Nodules and lenses of chert are common constituents of this formation.

Devonian and Mississippian Rocks Local discontinuous patches of quartzites, sandstone, sandy limestone, and limestone have been found in the area containing fossils representing Devonian and Mississippian times. These rocks are not important insofar as the clay deposits are concerned as they are of limited distribution. They are records, however, in the geologic history of the area.

Pennsylvanian Rocks These rocks are of primary importance in any consideration of the diaspore and flint fireclay deposits. The clays are found in this series, and consequently the distribution of these rocks outlines the areas from which clays have been produced or may be expected in the future.

The Pennsylvanian series as developed in the north central Ozark region is composed of slightly conglomerate sandstones, diaspore, burley, plastic and flint fire clays, shales, and thin discontinuous limestones. The rocks present are representatives of the Cherokee (Pottsville) formation, which has a widespread distribution in east central Missouri and to some extent in the St. Louis district, and in which occurs the hard, plastic, semiflint clay of the so-called Cheltenham seam. Apparently the rocks in this area were connected at one time with those in the other areas mentioned. Isolated patches of limestone representing a younger formation, the Henrietta, also have been found in the area.

Complete sections of the Pennsylvanian series have been noted in several deposits, but with the exception of the sandstones at the base, which are of considerable areal extent, the other rocks are preserved only in the sink-hole type deposits.

Rocks younger than the Pennsylvanian have not been recognized, although deposits of gravel, probably marking the courses of former streams, and tentatively assigned to the Tertiary, have been noted.

Structure The major structural features of the area are two belts of faulting and a low broad fold which control to a large extent the distribution of the Pennsylvanian rocks. The eastern side of the field is terminated by a major fault striking in a general southwest-northeast direction. Along the west or downthrown side of this fault, Pennsylvanian rocks are well exposed, with the older formations being exposed on the east or upthrown side.

The other zone has a general northwest-southeast strike, and traverses the central part of the district. The east side is downthrown, and the area between the belts of faulting is a downthrown block, in which a considerable thickness of Pennsylvanian rocks is found. The upthrown side of this zone appears to be a low broad fold on the west side of which Pennsylvanian rocks are found, with older rocks, chiefly those of the Roubidoux formation being present on the crest. The faulting and folding are significant, particularly in the upland areas, where the Pennsylvanian rocks are thin or entirely missing. Consequently these parts of the area offer no promise of producing clay.

Clays of the District

Diaspore Clay This slightly plastic, light gray, buff- or red-colored, high alumina clay is generally of a rough open-textured porous nature, although a dense, rocklike ore has been mined from a few deposits. The most striking feature of this material is the presence of oölites or shotlike particles, determined microscopically by Wherry[8] and

[8] E. T. Wherry, "Diasporite in Missouri," *Amer. Mineralogist*, II, No. 12 (1917).

Ries[9] to be composed of the mineral diaspore, which is the basis of the characteristic high alumina content. The oölitic particles occur in a porous groundmass of extremely fine-grained clay constituting approximately 10% of the whole. The results[10] of laboratory studies of this material show that it is complex as to chemical composition and physical properties.

As defined in the district, the diaspore clay carries a minimum content of 70% alumina and shipments are made on this basis. Such clay usually carries a maximum silica content of 10% or less, and the determination of the percentage of this constituent might well be used in determining the quality of the clay. Lime, magnesia, and alkalis are variable, but usually do not occur in large amounts. Some information has been obtained that indicates a slight increase in these constituents as the clays continue in depth within certain deposits. The lighter colored varieties of clay contain very little iron, but the content increases in the buff- or red-colored clay. The diaspore clay, as in the case of many bauxites appears to be comparatively high in titania, which is present in amounts ranging from 3% to over 4%. In this connection it is interesting to note that the plastic clay groundmass is also quite high in titania.

A peculiar type of ore, capping several deposits, shows alternating bands of hematite and diaspore clay with the latter forming a central core. This material, the "iron-band diaspore" of the district, has no commercial value. It is an important guide, however, in prospecting, due to its resistance to weathering and occurrence as surface or float boulders over some deposits.

TABLE I

ANALYSES OF CLAYS, NORTH-CENTRAL OZARK REGION MISSOURI

(Analyses by H. W. Mundt)*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Silica	42.68	15.60	11.58	3.89	7.44	4.82	30.70
Alumina	38.49	64.46	68.50	76.21	73.58	77.33	37.03
Ferric oxide	1.55	0.42	0.88	0.98	0.93	0.75	3.15
Titania	2.90	2.60	3.40	3.52	3.99	2.83	13.37
Lime	0.00	0.92	0.26	0.08	[a]	0.13	[a]
Magnesia	0.08	1.52	0.13	0.06	[a]	0.33	[a]
Soda	0.28	0.37	1.34	0.79	[a]	[a]	[a]
Potash	0.49	0.81	0.46	0.24	[a]	[a]	[a]
Ignition loss	14.07	13.52	13.91	14.20	14.12	14.12	10.56
Total	100.54	100.22	100.46	99.97	100.06	100.31	94.81

* Chemist, Missouri Bureau of Geol. and Mines.

[a] Not determined; (1) flint fire clay, Gasconade County; (2) burley clay, Franklin County; (3) burley clay, Gasconade County; (4) diaspore clay, Maries County; (5) diaspore clay, Maries County; (6) heavy particles, derived from mechanical fractionation of No. 5 constitutes 90% of original sample; (7) plastic clay derived from mechanical fractionation of No. 5 constitutes 10% of original sample.

[9] H. Ries, "High Grade Clays of the Eastern United States," U. S. Geol. Surv., *Bull.*, No. 708, p. 138.

[10] Press notice, Mo. Bur. of Geol. and Mines, May 30, 1925.

Flint Fire Clay This clay is one of the most remarkable fire clays found in Missouri. It occurs in the area north of the Missouri River and to some extent in Cole, Morgan, and Miller Counties, west of the district under discussion. Regardless of the locality, flint fire clay seldom shows any great variation in chemical or physical properties except the rough or oölitic varieties found to some extent only in this district.

All of the clay deposits of the north-central Ozark region contain flint fire clay. It is generally smooth, hard, fine-grained and has a distinct property of breaking with a shell-like fracture and with sharp, splintery edges. It varies in color through shades of white, gray, dark gray, blue-black, buff, and red. The color of the darker varieties is due to the presence of organic matter, and in some instances lenses of coal are found in close association with this clay. The buff and red colors are due to the presence of iron, which destroys the value of the clay insofar as the manufacture of fire brick is concerned.

The oölitic type contains rounded particles of the mineral diaspore embedded in a matrix of flint fire clay. As the material becomes increasingly oölitic, with a consequent rise in alumina content, it is mined under the local names of "rough flint," "burley" flint, or "burley" clay. This last mentioned will be described later in more detail.

Typical analyses of smooth flint fire clay are given in the tables.

Burley Clay This name was given by the miners, during the early development of the high alumina clay, to the material characterized by the presence of oölites or "burls;" hence the name. For years, the term has been a misnomer in that it may include any clay from a slightly oölitic flint fire clay to open-textured, very oölitic, diaspore clay. Consequently, this material varies in chemical composition and in physical properties.

Constant usage has resulted in the name becoming well established and it probably will be retained throughout the life of the district. In the last few years, however, an attempt has been made to classify this clay on the basis of alumina content, and shipments have been made as No. 1 burley clay, containing 65 to 70% alumina; No. 2 burley clay, containing 60 to 65% alumina; and No. 3 burley clay containing less than 60% alumina. Analyses of burley clay are given in the table showing the composition of clays from this part of Missouri.

Plastic Clay Two varieties of plastic clay are found in some deposits. One is a hard, semiflint fire clay apparently the result of prolonged weathering of the nonplastic flint fire clay. The other is an extremely fine-grained, soft, plastic clay, locally known as "talcum powder" clay. It is sometimes marked by the presence of oölites containing the mineral diaspore. Both clays have been used to some extent as a bond in

the manufacture of refractories. They are limited in occurrence, however, and are not important, considering the district as a whole.

Other Materials Coal is found in a number of deposits. It is usually of the cannel or low rank bituminous type. It varies in thickness from thin lenses, up to masses having a thickness of 100 feet, although the latter is exceptional and has been noted in only one deposit, located near Anaconda, Franklin County. The coal appears to be closely associated with the flint fire clays, but apparently has no direct relation to the other clays.

Other materials noted are thin fossiliferous limestones and shales, which cap a few deposits. These rocks are of Pennsylvanian age, but were deposited after the clays and coal. They are records of the geologic history of the area, and the fossils found are of value in correlating the formations with those in other clay-producing districts.

Mode of Occurrence

The characteristic inverted, cone-shaped, sink-hole type deposits, in which the clays are found without exception, are lined or surrounded by a rim-rock of Pennsylvanian sandstone. This rim-rock is an important guide in prospecting, exploring, or developing a deposit. The margins of the deposits are often marked by outcrops of highly dipping sandstone beds, indicative of the presence of a sink structure, and in this particular area, of a clay deposit. The rim-rock occasionally outlines the surface dimensions of the deposits; in drilling it marks the margins of the clay-filled structure, and in mining it denotes the limits of clay-bearing areas.

In surface plan, the deposits are elliptical or circular in shape. They vary in size from small "pot holes" to a maximum known length of 800 feet. They are irregular as to depth, some being shallow depressions, while others are 100 feet or more.

Within these cone-shaped deposits are found the clays described. Flint fire clay occurs in all of the deposits, but the occurrence of the others is more limited. Diaspore clay has been found in commercial quantities in approximately one out of every four deposits; burley clay appears to be more common in occurrence and plastic clays less common than diaspore. The occurrence of burley and diaspore clay within the deposits is very irregular. They are sometimes found as a central core, and Wysor[11] believed this occurrence to be general. A study of the deposits made by the writer indicates this to be true in some instances. Many of the others, however, contain masses of diaspore clay which outcrop at the surface, but dip steeply toward a structural center; the overlying material being burley or flint fire clay. Masses of diaspore clay are also found at con-

[11] D. C. Wysor, "Diaspore Clay of Arkansas and Missouri," *Jour. Amer. Ceram. Soc.*, **6** [3], 502 (1923).

siderable depths in the deposits, either interbedded with other clays or as associated irregular, lenticular masses. A gradation from flint clay to diaspore clay has been noted in some instances.

The deposits, while possessing the same general features, show different degrees of fracturing. Some are marked by more gently dipping rim-rocks and are in effect gentle basins; others show steeply dipping or vertical rim-rocks, and highly-fractured masses of clay. These deposits appear to contain more diaspore clay than the less fractured ones, the material being associated with the other clays in the zones of greatest fracturing, chiefly adjacent to vertical or highly inclined rim-rocks. A splendid example of the association of diaspore clay to fractured zones may be seen in a deposit near Rolla. Here the mass appears to decrease in size and to be less persistent as depth is reached. It is confined to that portion of the deposit adjacent to a highly-inclined, faulted, rim-rock, no diaspore clay being found on the opposite side, which is not marked by any great fracturing. The localization of diaspore, as described, appears to be of some significance in any consideration of the origin.

The sink-hole type of structure was recognized by Wheeler[12] in his study of the area. He believed they were formed as the result of solution of the underlying dolomites, and the resulting basins subsequently filled with clay. Since the time of his study, and with the development of the district, additional information has been obtained. In connection with a study of the clays of this area the writer has been impressed by the features developed as the result of underground drainage. The Ozark region is noted for its large springs, sink-holes, caves, and to some extent for a number of comparatively wide valleys, which support surface drainage only in periods of excessive rainfall. During the dry seasons the courses of these streams are dry or marked by ponded bodies of water, the inference being that the major portion of the surface water is diverted into the underground drainage.

A study of the rock formations in and adjacent to the clay district shows that the features mentioned are most characteristic of the dolomites of the Gasconade formation. It is also of interest again to note that in the same general area, deposits of hematite (red iron ore) are found in sink structures, which are similar to those in which the clays occur. They are lined, however, by sandstones of the Roubidoux formation, although the caverns which they occupy were formed in the underlying Gasconade rocks. There is little evidence that solution has been effective in the Jefferson City, and certainly not in the Roubidoux formation, which is composed chiefly of sandstone. The former is exposed in the vicinity of several deposits, and as the periphery is reached, the beds dip steeply

[12] H. A. Wheeler, "Clay Deposits," *Mo. Geol. Surv.*, **12**, 202 (1896).

and roughly in accordance with that exhibited by the sandstone rim-rock lining the structure. In these instances the caverns were formed probably some distance below the contact of the Pennsylvanian and Jefferson City formations. In those parts of the area where the latter, and the underlying Roubidoux formations are thin, it is apparent that these clay-filled sinks occupy caverns found in the relatively more soluble Gasconade dolomite. That these clay-filled sinks were connected with Gasconade caverns has been indicated also by Lee,[13] who cites the occurrence of fire clay associated with broken material in a sink-hole, unquestionably formed in the Gasconade.

The foregoing discussion is of interest, as the writer's studies indicate that the Pennsylvanian clays and associated rocks were not deposited in pre-existing sink-holes, but slumped into them after deposition. The gradation of the basal Pennsylvanian sediments through sandstone, sandy clay, and clay is a significant fact. Apparently they were laid down during the same general geologic time, and represent a gradual or transitory change in the character of the materials being deposited. This zone is now often highly colored, reds and purples being common. In some deposits the dip of bedding planes in the clays corresponds, in a general way, to that of the rim-rock, and again indicates that both were involved in the slumping. The most conclusive evidence of slumping of the mass into caverns after deposition is shown by the fractured and brecciated nature of the clays and the associated rocks. Local faults, slicken-sides, and well-defined joints are common. These features shown in the clays, the sandstone wall rock and the adjacent rocks of pre-Pennsylvanian age are significant of movement, and the similarity in structural relations indicates the slumping of the mass after the deposition of the clays.

Origin of the Clays

The problem of the origin of the clays has been one of the interesting phases of the investigation. The final field and laboratory studies have not been completed, but the suggestions made below are tentatively offered.

The Pennsylvanian rocks appear to have been deposited in this part of the State as a series of some continuity and areal extent. The initial deposits were sand, followed by finely-divided clayey materials, and finally by shales and limestones. The flint fire clays, and possibly the oölitic or rough varieties appear to have been deposited as such, although possibly somewhat altered later. Caverns were formed by solution in the underlying dolomitic rocks and the clays and associated materials slumped into the structures, the surface reflections of which are now ex-

[13] Wallace Lee, "The Geology of the Rolla Quadrangle," *Mo. Bur. Geol. and Mines*, **12**, 69 (1913).

pressed by the characteristic sink-hole type deposits. These sink-hole deposits, many of which had direct connection with the subterranean drainage, would be favorable places for the circulation of descending solutions, particularly in those that exhibit a considerable amount of fracturing of the materials adjacent to or within the deposits.

The porous, open-textured character of the diaspore clay, its irregular occurrence in the fractured zones, and its presence in some deposits as a surface capping are suggestive of leaching. As shown by Ross,[14] aluminous enrichment can result from the leaching of silica and the chemical composition of the Missouri clays indicates that this may be true. A study of many analyses of the clays from this district shows a gradation in chemical composition from that of the average flint fire clay to that of the high-grade diaspore clay. This gradation may also be seen in the clays.

The relatively high content of titania in the diaspore clay, as compared with the other clays, is suggestive of concentration of this relatively stable constituent. The low content of alkalis and alkaline earth metals is significant. In some deposits these constituents are comparatively low in the clay in the upper part of the deposits, but reliable information, obtained in the course of the field studies, indicates small, but higher amounts within the same mass as it continues in depth. This appears to be particularly true of burley clay, and indicates incomplete leaching or possibly a complete saturation or soaking of the clays, a slower circulation of the leaching solutions, or closing of the openings connected with the underground drainage. Adams[15] describes the Georgia-Alabama bauxite deposits as occurring in sink-holes, and suggests alteration of the clays in the depressions. Later the same writer[16] has suggested that the occurrence of bauxite in the southeastern states and of diaspore clay in Missouri are very similar. Rettger[17] has also described the bauxite deposits in southeastern Alabama as occupying irregularities in the surface of the Tertiary (Clayton) limestone, with which the material is associated. He suggests surface alteration of clays to bauxite within these pockets.

In connection with a study of these sink-hole deposits, it is interesting to note that diaspore clay is not found in the pocket deposits of flint fire clay occurring in east-central Missouri. Here the clays are found in depressions in the chert conglomerate marking the base of the Pennsylvanian series. In one instance in this area (Central Lincoln County), a rough, oölitic to slightly porous, burley clay is found in a sandstone-lined

[14] D. W. Ross, "Nature and Origin of Refractory Clays," *Jour. Amer. Ceram. Soc.*, **10** [9], 712 (1927).

[15] G. I. Adams, "The Formation of Bauxite in Sink-holes," *Econ. Geol.*, **18** [4], 410–12 (1923).

[16] "Bauxite Deposits of the Southern States," *Econ. Geol.*, **22** [6], 620 (1927).

[17] R. E. Rettger, "Bauxite Deposits of Southeastern Alabama," *Econ. Geol.*, **20** [7], 671–86 (1925).

deposit, similar to those described. This is the only occurrence of high alumina clay in Missouri, outside the north central Ozark region observed by the writer. It again suggests that sink-holes, particularly those with outlets at the bottoms, are favorable places for the alteration of the original clays to diaspore clay.

Future of the District

The high alumina refractories industry is alive to the fact that the present rate of consumption of diaspore clay will exhaust, within a comparatively short time, the material occurring in the deposits found to date. Apparently the future of this industry lies in the discovery of new areas and in new deposits.

In the district under discussion, a thousand sink-hole type deposits have probably been found. One-half to possibly three-fourths are of commercial size, but of these, only slightly more than one-fourth contain diaspore. It appears that the largest number of deposits marked by some surface expression, which serve as a guide in prospecting[18] have been found, although a few additional deposits have been recently discovered. For some time the writer has been impressed by the flat upland surfaces of the area, which are known to be underlain by the Pennsylvanian series. To date, only a few clay deposits have been discovered in these areas, the largest number of the deposits having been found around the "breaks" or margins. During the past year, however, a deposit larger than the average has been found in what is locally called "prairie" country. The surface was devoid of any suggestion of a deposit, and its presence was indicated in turning up a boulder of very high-grade diaspore clay in plowing. Additional deposits may be expected in these areas. They will only be found by systematic drilling, based on facts observed in the course of field studies, or possibly by means of prospecting, not utilized at present. At any rate, until these upland areas are thoroughly prospected, and the clay resources definitely determined, the district cannot be said to have reached its maximum development.

MISSOURI BUREAU OF GEOLOGY AND MINES
ROLLA, MISSOURI

[18] For a detailed discussion of prospecting and mining methods the reader is referred to C. R. Forbes, "Winning of Missouri Diaspore, Burley, and Flint Clays," *Jour. Amer. Ceram. Soc.*, **11** [3], 204–14 (1928).

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Hoping for a prompt affirmative response, I am,

Yours very truly,

G. A. BOLE, *President*,
AMERICAN CERAMIC SOCIETY

CERAMIC ABSTRACTS

Compiled by the

AMERICAN CERAMIC SOCIETY

ROSS C. PURDY, Editor

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Abrasives

Tungsten-carbide cutting tools. H. J. Long and W. P. Eddy. *Mech. World*, **86** [2219], 40–41 (1929).—It is impossible to cut completely through even a thin piece of this alloy with a grinding wheel because the piece always fractures before the process is finished. It was found that to grind on one side only, preferably the broader one, directly into the piece until it cracks, is a sure method of giving a flat fracture in the desired plane. With this method the feed of the wheel into the work, within reasonable limits, appears to have little influence on the result. A 7-in. wheel not less than $^3/_8$-in. thick was used, on the circumference of which had been dressed a rim approximately $^1/_{16}$-in. thick and $^1/_4$-in. wide, with fillets at the shoulders and with a rounded edge. The tip or blade may be ground to its final shape after mounting. The authors have occasionally encountered tips which by their crumbling defied all efforts to grind a good edge. Machine lapping with an aluminum disk was developed on which was brushed a fine silicon-carbide paste. This served the purpose fairly well, although there were still some edges which required finishing with a hand lap of brass. A fixed position on a surface grinder was found to result in a rounding or crumbling of the point; consequently they ground by hand, moving the tool across the side of the wheel. Good results in roughing are obtained with a certain Czechoslovakian silicon-carbide wheel and with 60–1 to 80–1 crystolon wheels; for finishing, a 100–1 crystolon wheel is satisfactory. Wheel speeds are approximately 3400 r.p.m. It is rarely found necessary to resort to lapping as the finishing operation; further improvement is possible by the

use of a still finer finishing wheel. Properties, uses, and development of tungsten-carbide alloys are discussed in detail. E.P.R.

Preparation of surfaces for chromium plating. ANON. *Brass World*, **25** [5], 118 (1929).—The Hill-Curtis Co., Kalamazoo, Mich., manufacturers of polishing and buffing supplies and equipment, have issued information on polishing and buffing of chromium plated work. The preparatory finish must be nearly perfect as the chromium will not cover up defects in the basic surface. One of the essentials for polishing and buffing is proper speed of buffing wheels. The recommended speeds of polishing and buffing lathes are: grinding, 1200 to 1800 r.p.m.; polishing, 1800 to 2200 r.p.m.; buffing, 2200 to 2700 r.p.m.; chromium buffing, 2700 to 3000 r.p.m. "Chrome buffing," or "color buffing" requires 2700 to 3000 r.p.m. E.P.R.

Grinding of metals and alloys. ANON. *Brass World*, **25** [3], 57 (1929); *Grits and Grinds.*—Some interesting information on precision grinding of nonferrous metals and alloys in Norton Co. E.P.R.

Combination grinding and polishing machine. ANON. *Brass World*, **25** [5], 114 (1929); *Abrasive Ind.*, **10** [6], 43–44 (1929).—For abstract see *Ceram. Abs.*, **8** [8], 548 (1929). E.P.R.

Polishing lathe. ANON. *Brass World*, **25** [3], 59 (1929); *Abrasive Ind.*, **10** [5], 44–45 (1929).—For abstract see *Ceram. Abs.*, **8** [8], 547 (1929). E.P.R.

Burnishing materials. ANON. *Brass World*, **25** [5], 109 (1929).—The Abbott Ball Co., Hartford, Conn., manufacturers of various types of ball burnishing materials and equipment, are issuing free a small kit of burnishing materials containing samples of its products which are used in certain metal finishing processes. E.P.R.

Two-spindle electric polisher. ANON. *Brass World*, **25** [6], 140 (1929); *Abrasive Ind.*, **10** [6], 43 (1929).—For abstract see *Ceram. Abs.*, **8** [8], 550 (1929). E.P.R.

Polishing machine. ANON. *Brass World*, **25** [6], 144 (1929).—A number of special features have been incorporated in a new type of buffing and polishing machine which has been designed and placed on the market by the Hisey-Wolf Machine Co., Cincinnati, Ohio. The new equipment is known as the "Texdrive" due to the use of a Texrope driving belt. E.P.R.

PATENTS

Dressing grinding wheels. ALLAN H. CANDEE AND GEORGE O. RICHMOND. U. S. 1,721,103, July 16, 1929. The method of dressing a grinding wheel for grinding the gashes of a spirally gashed hob, which consists in moving a truing element repeatedly across the active face of the grinding wheel while imparting a relative motion between the wheel and truing element exactly corresponding to that which takes place between the wheel and hob during the grinding of the gashes.

Grinding machine. HARRY G. MILLER. U. S. 1,721,309, July 16, 1929. A cutter grinder comprising a grinding wheel, a rotatably adjustable column, mounted in suitable proximity to the wheel and provided with a plurality of bearings adapted to receive cutters of varying angles, the axes of the bearings lying in a plane perpendicular to the axis of rotation of the column, the axes being varjably positioned with reference to the axis of the column, so that the respective cutters may be brought into proper relation with the grinding wheel, and means for varying the distance between the grinding wheel and column to carry the work into and out of grinding position.

Work-rest blade for centerless grinders. HAROLD SKALL. U. S. 1,721,475, July 16, 1929. A wear-resisting work-supporting blade for centerless grinders, comprising a cast-metal alloy of iron, carbon, silicon, manganese, phosphorous, and chromium, the supporting face of the blade having a chill of some depth with a hardness of at least 50 Rockwell C numerals and a chill face of a natural smooth and dense nature adapted to resist deposit and piling up of grindings in actual use.

Cylinder-grinding lap. OSCAR C. KAVLE. U. S. 1,722,301, July 30, 1929. In a cylinder grinding device, the combination of a cylindrical head having reduced ends and radial lengthwise grooves between the reduced ends, peripherally threaded collars removably mounted on the reduced ends, lap-supporting bars movable radially in the grooves and having their opposite ends abutting against the collars and provided with outwardly converging flanges projecting beyond the peripheries of the collars, internally threaded nuts engaging the threaded peripheries of the collars and outer end faces of the flanges, abrasive laps having their opposite ends engaged with the inner faces of the flanges, and means for yieldingly holding the bars in engagement with the flanges.

Centerless grinding machine. CHARLES H. NORTON. U. S. 1,722,386, July 30, 1929. (1) In a grinding machine, in combination, a grinding wheel, a support to hold round work in operative contact with the wheel and providing a path of travel for the work past the operative surface of the grinding wheel; means for rotating the grinding wheel; means for rotating the work on the support; and means to move the work in the direction of its axis and along the path of travel provided by the support, while the work is rotating, and into substantially full grinding contact with the grinding wheel, then to cause halting of the work on the support to permit it to be ground while rotating and remaining immovable in an axial direction, and thereafter to move the work, while being rotated and ground, along the support and out of operative relation to the wheel. (2) U. S. 1,722,387. In grinding apparatus, in combination, a grinding wheel, a work rotating wheel, means for driving the grinding wheel at a grinding speed, means for driving the other wheel at a relatively low speed to control the rotation of work of round section interposed between it and the grinding wheel, the wheels presenting adjacent operative surfaces traveling in opposite direction, a work support movable in the direction of the grinding throat formed by the two wheels, and adapted to hold thereon work of round section against displacement relative to the work support as the latter is moved, means for guiding the work support in a path of movement extending in the general direction of the grinding throat, and power actuated means for moving the support along the guiding means and thereby move the work supported thereon into operative contact with the adjacent operative surfaces of the two wheels.

Grinding small cylindrical objects. CHARLES H. NORTON. U. S. 1,722,388, July 30, 1929. The method of grinding work-pieces of round section in a grinding throat having included therein a grinding wheel and a work rotating wheel, which method consists in moving a work-piece axially into the grinding throat so that, while the work rotating wheel rotates the work, the grinding wheel takes a peripheral cut progressively along the work-piece as the latter is moved relative to the grinding wheel; halting the axial movement of the work-piece to permit the grinding wheel to grind itself out throughout the axial extent of the work-piece engaged by the grinding wheel; placing a second work-piece in back of the halted work-piece; and moving the second work-piece axially in a direction to cause it to move the first work-piece in a direction out of the grinding throat and to effect entry of the second work-piece into the grinding throat, the grinding wheel acting during the last-mentioned axial movement of the first work-piece to substantially finish grind the surface of the latter.

Apparatus for feeding continuous-working wood grinders. WILHELM RABUS. U. S. 1,722,395, July 30, 1929. Apparatus for feeding wood grinders comprising a magazine for receiving a charge of logs, a grindstone coöperating with the magazine, and means for compressing the wood charge directly toward the grindstone, the means comprising rotary members having pressure plates extending tangentially outward therefrom entering into and passing into the magazine under rotary movement for collecting certain logs of the charge between successive plates and pressing them toward the grindstone, the pressure member entering beyond the lateral side of the magazine

and into the charge and within the median line of the charge and such pressure means further keeping the charge away from the magazine walls so as to avoid friction between the charge and the walls.

Valve-grinding tool. GEORGE S. ISKYAN. U. S. 1,722,577, July 30, 1929. A valve-grinding tool, comprising an upright spindle for turning the valve, a driving shaft disposed at an angle to the spindle, means operated by the shaft for imparting oscillatory movement to the spindle, a housing supported on the spindle and enclosing the means and a bearing member mounted in the housing and supporting the shaft adjacent its opposite ends.

Work-feeding device for vertical disk grinders. JOHN MILLER, JR. U. S. 1,722,589, July 30, 1929. In a grinding machine of the character described, the combination of a grinding disk rotative in a horizontal plane, means for guiding the work to be ground in a predetermined path across the face of said disk, and a plurality of vertically adjustable plates suspended above the path of the work and bearing edgewise thereon.

Grinding machine. CHARLES E. VAN NORMAN. U. S. 1,722,691, July 30, 1929. In a machine of the class described, a heavy base, a work head pivoted for oscillation about an axis in the base, a work holder rotatably mounted in the work head, a belt pulley fixed to the work holder for rotation therewith, a belt pulley axially in line with the pivot axis of the work head but independently mounted in the base frame, a belt connecting the two pulleys, means for oscillating the work head, and means for rotating the second-named belt pulley.

Valve-grinding machine. FRANS O. ALBERTSON. U. S. 1,722,880, July 30, 1929. In a machine of the class described, the combination of a base, a first slide movable thereon, a grinding wheel supported on the slide, an electric motor on the slide, a second slide movable on the base, power driven work-holding means on the second slide, a shaft extending below the top of the base, a bearing for one end of the shaft moving with the first slide, means connecting the electric motor with the latter end of the shaft, a bearing for the other end of the shaft moving with the second slide, and means for connecting this other end of the shaft to the work-holding means.

Centerless grinder. GEORGE W. BINNS. U. S. 1,723,128, August 6, 1929. A centerless grinder including opposed grinding and regulating wheels and an intermediate work rest, a rotary carrier having a plurality of work supporting portions for successively presenting work-pieces on the work rest between the wheels, and means for ejecting the finished work-pieces.

Grinding, polishing, and buffing machine. CHARLES G. JOHNSON. U. S. 1,723,622, August 6, 1929. In a grinding and polishing machine, an abrasive wheel, a work support mounted for substantially universal movement including lateral and longitudinal rocking movements, means for shifting the support to present the work to the wheel, and cam means for determining the height and angular position of the support as it passes by the wheel.

Grinding machinery. FRED S. HAAS. U. S. 1,723,852, August 6, 1929. In a grinding machine the combination with a work-supporting member and a grinding wheel for action on work held thereby, of means for positively producing relative movement between the parts, comprising a feed screw carried by one of the parts; a nut member associated with the other of the parts and fluid pressure mechanism for insuring constant contact between one face of the interengaging threads on the nut and screw.

Swing-frame grinder. FRANK E. STRATTON. U. S. 1,724,050, August 13, 1929. (1) In a swing-frame grinder, a grinding wheel, a hydraulic motor to drive the wheel, a hydraulic pump connected to the motor, means to drive the hydraulic pump, means to increase the stroke of the motor to increase the speed of the hydraulic pump and grinding wheel as the wheel wears down in use and means adapted to contact the grinding

wheel and connected to the stroke changing means to prevent movement thereof to increase the driven speed of the wheel until the wheel has worn down in use. (2) U. S. 1,724,115. In a swing-frame grinder, a support, a frame, means to fulcrum the frame on the support, a grinding wheel mounted on the frame on one side of the fulcruming means, a motor to drive the wheel mounted on the frame on the opposite side of the fulcruming means, driving mechanism for the wheel actuated by the motor, an operating handle attached to the frame adjacent the wheel, speed-changing means interposed in the driving mechanism, means including a manually operated movable member adjacent the operating handle to shift the speed-changing means to increase the driven speed of the wheel as the wheel wears down in use, means to lock the speed-changing means at set predetermined positions thereof, and means adapted to contact the wheel and connected to the speed-changing means to prevent movement of the speed-changing means to increase the driven speed of the wheel until the wheel has worn down predetermined amounts in use.

Feeding abrasives to grinding machines. JOSEPH P. CROWLEY. U. S. 1,724,259, August 13, 1929. An apparatus for supplying abrasives to a plurality of sheet-surfacing machines, comprising a plurality of reservoirs, for different grades of abrasive, a conduit from each reservoir extending past the several machines, and back to the reservoir, means in each conduit for forcing the abrasive therethrough, and means adjacent each machine for selectively feeding abrasive to the machine from the conduits.

Machine for grinding hobs, worms, etc. JOHN EDGAR. U. S. 1,724,699, August 13, 1929. A grinding machine having, in combination, a grinding wheel, a slide means on the slide for rotatably supporting a hub, etc., with its axis extending in the direction of movement of the slide, a feed screw for moving the slide, a nut on the screw, means connecting the nut to the slide, and power means for adjusting the connection to move the slide with relation to the nut longitudinally of the screw.

Centerless grinding. CINCINNATI GRINDERS, INC. Brit. 311,328, July 3, 1929. A centerless grinder for tapered rollers consists of a bed having adjustably mounted thereon a grinding wheel, which is reciprocated axially during grinding, and a regulating wheel. Supported on the bed below the wheels is a cam plate, reciprocated parallel to the wheel axis by a lever oscillated by a cam groove in a drum on the shaft of the regulating wheel.

Grinding or abrading machines. V. A. B. HUGHES. Brit. 311,489, July 3, 1929. A grinding machine wherein the work is positively rotated about a definite axis located therein during grinding, comprises grinding and regulating wheels and pivotally mounted centers for supporting the work between the wheels so that the axis of the work may move away from the regulating wheel and have a component along the operative surface of the grinding wheel when the regulating wheel engages a protuberance on its surface.

Grinding toothed blades. R. C. V. ELLIS. Brit. 311,523, July 3, 1929. Teeth or serrations are ground in the edge of a blade by means of a grinding-wheel formed with a helical cutting-edge the work being traversed across the wheel at the screwing rate of the helical edge either by hand, the edge serving to maintain the traverse, or by movement of a slide moved on guides by a screw and a nut segment pivoted to the slide, and movable into engagement with the screw by a handle. The screw is rotated from the main shaft through worm gearing and bevel gearing, a clutch being provided. The helical edge is formed by grooving the wheel by means of a diamond or other tool carried by a pivoted holder on the slide and a single or multiple thread may be formed on the wheel. The work is tilted longitudinally so that the tips of the edges first engage it; or the wheel may be slightly conical, the work then being traversed in a direction parallel to the axis of the wheel.

Gear-grinding machines. MOSS GEAR CO., LTD., AND E. GREGORY. Brit. 311,597, July 10, 1929. The grinding wheels employed in the production of worm gearing are prepared or trued by means of a device comprising oscillating diamond tools for trimming the sides of the wheel and a separate tool for operating upon the peripheral edge. A stud is screwed into the frame of the machine and carries a split sleeve secured by a screw and having a depending bracket portion which straddles the grinding wheel. Extensions on the bracket are fitted with plates adapted to bear on fixed projections on the machine frame. Each leg of the bracket is bored to receive the trunnion of a casing which accommodates a T-shaped sleeve. The horizontal portion of this sleeve carries the sliding holder of the diamond tool, adjustment being effected from a micrometer head. The upper end of the sleeve carries a screw cap which may be locked by a plunger and screw. The stud also carries a sleeve adjustable by a screw and having a depending portion. This sleeve carries a loose sleeve on the upper end of a holder carrying a diamond for trimming the periphery of the wheel. For the preliminary trimming of the side faces, the wheel is rotated and the casing is swung about the trunnion. The side face is then radiused by swinging the casing into engagement with a stop, releasing the cap, and rotating the sleeve about its axis, the diamond thus moving in an accurate path in a plane containing the grinding wheel axis.

Grinding nuts, etc. A. JOPP. Brit. 311,731, July 10, 1929. A machine for grinding simultaneously two opposite surfaces of prismatic articles, *e.g.*, nuts, consists of a table on which are mounted pairs of slides adjustable by screws and carrying hollow spindles, the number of pairs of slides corresponding to the number of pairs of faces on the work. Secured on the spindles by bolts having heads and by nuts on the outer ends of the bolts, are grinding wheels consisting of concentric cylinders, the outer cylinder being of coarse grain, and the inner of fine grain, the operative faces of the wheels being conical, and the spindles being inclined as shown. The nuts are introduced into a tube between the pairs of grinding wheels, the internal cross-section of the tube corresponding to the shape of the nuts, and are fed forward by the wheels, which contact with the nuts below the axes of the wheels, openings being provided in the tube opposite the wheels. Between the pairs of wheels the tube is twisted so as to turn the nuts to present new faces to the succeeding pair of wheels; the coarse-grained cylinder acts first on the nuts, the fine-grained cylinder then giving a fine grinding.

Gear-cutting. GLEASON WORKS. Brit. 311,765, July 10, 1929. A taper or cylindrical hob for cutting gear teeth particularly bevel or hypoid gears having longitudinally-curved teeth is provided with side faces which are of continuously-varying pressure angle from one end of the hob to the other. A taper hob of this form may be used to produce taper gears having side faces which are of substantially constant pressure angle from end to end of the teeth measured circumferentially of the gear. Further, the proportional taper in the tooth thickness is the same as the proportional taper in the depth.

Centerless grinding machines. B. S. A. TOOLS, LTD., AND W. OGILVIE. Brit. 311,931, July 10, 1929. A machine for the centerless grinding of a work-piece having portions of different diameters is provided with a spring-controlled pressure-roller mounted on the head of the grinding wheel and adapted, when the grinding-head is moved toward the work, to hold the larger diameter of the work against the controlling wheel so as to rotate the work while permitting further advance of the grinding wheel into contact with the smaller diameter.

Grinding and polishing wheels. H. NEILSEN. Brit. 312,001, July 10, 1929. A grinding or polishing wheel consists of a hub upon which a strip of abrasive cloth is wound, the inner end being placed in an incision. The turns of cloth are secured together by glue upon the side faces of the wheel, or by gluing thereto a sheet of paper,

cloth, etc. The hub may have bevelled corners to keep the edges of the strip below the operative surface; a fresh surface is presented by unwinding a turn of the strip and tearing it off.

Grinding machines, etc. L. KELLENBERGER. Brit. 312,176, July 17, 1929. In a grinding machine or other machine tool, the tool spindle carrying grinding disks at its ends is mounted in a headstock, which is rotatably adjustable, and also may be adjustable vertically, in a base, upon which also is mounted a reciprocating work table carrying work centers. The spindle is driven, through tension rollers, by a belt and a pulley driven by bevel gearing from a vertical shaft, which is driven, through bevel gearing and belt gearing, from an electric motor. In a modification, the tool headstock is not adjustable vertically, the work table being carried by a vertically adjustable bracket.

Grinding razor blades. S. LARSSON. Brit. 312,550, July 24, 1929. In a grinding machine, shown as applied to grinding razor blades, the grinding wheel is fed toward a reciprocating trimming tool and the blades are moved across the wheel by an endless band carried by a guide in such position that the blade edges contact with the wheel just in front of the path of the tool.

Truing grinding-disks. E. KREIS, A. RICKENMANN, AND REISHAUER-WERKZEUGE AKT.-GES. Brit. 312,925, July 24, 1929. Apparatus for truing profiled grinding tools for grinding screw threads consists of two slides movable at right angles over the machine frame, the slide carrying a rotary slide on which is mounted a slide adjustable by a screw and having slidable therein a sleeve in which is a spindle, carrying a grinding wheel and driven by a flexible shaft. The sleeve has thereon teeth engaged by a pinion movable by a hand lever and on the slide a carrier is removably mounted carrying a diamond adjustable by a graduated drum. The slide is set to the angle required by scales and its movement is limited by stops.

Grinding or abrading machines. A. E. WHITE. Brit. 313,279, July 31, 1929. The invention is shown as applied to the internal grinding machine described in Brit. 257,670 and consists of a reciprocating table carrying the grinding wheel, the work being supported in an automatic chuck carried by a head on a bridge.

Abrasive wheels. G. W. PERKS CO. Brit. 313,517, August 8, 1929. A grinding wheel having side plates secured thereto by intermediate layers of rubber or the like and adapted to be held on a spindle by clamping-plates has the plates formed with scorings, so that as the wheel wears, strips of the plates can be torn off to reduce the diameter thereof, *i.e.*, by wrapping the torn strip on a slotted key. The plates may be secured to the wheel by spraying the wheel with liquid rubber compound, applying to the plates, by means of the compound, a thin layer of rubber, inserting the wheel with the plates thereon in a press, and vulcanizing the rubber.

Art

Effect on colored melts of additions of zinc oxide, rutile, and fluorspar. ANON. *Keram. Rundschau*, **35**, 253–55 (1927).—To four basic glazes the compounds of which are given, were added the same percentage amounts (2%) of either CuO, Cr_2O_3, Fe_2O_3, CoO, MnO_2, or Ni_2O_3. To a second series of the same compounds and with the same coloring oxides was added 2% ZnO, to a 3rd 2% TiO_2, and to a 4th 4% fluorspar. The glazes were applied to an earthenware biscuit and fired under oxidizing conditions until the glaze was melted properly. The colors and the characteristic appearance of the 96 samples thus obtained are described. H.I.

Iridescent luster. WOLFGANG HENZE. *Keram. Rundschau*, **35**, 159–61 (1927).—Iridescent lusters may be produced on all sorts of ceramic bodies and with a number of different types of glazes, provided that other conditions are right. A reducing at-

mosphere during the latter part of the glost firing or in a second low temperature glost firing is essential. This luster may be most easily obtained with a lead glaze to which rutile or ZnO has been added to obtain a mat effect. A dense body such as porcelain gives more satisfactory results than a porous body such as earthenware. After the glaze has been fused on the body the temperature is reduced to a bright red and naphthalene or petroleum is introduced through the peep-hole in the kiln and the kiln sealed up. This process is repeated, the number of repetitions depending on the size of the kiln. Too smoky a flame produces dark, mat flecks, too low a temperature fails to produce their iridescence, and too high a temperature causes bubbles. Formulas for a number of iridescent glazes of different colors are given. H.I.

Glass decorating patent. ANON. *Amer. Glass Rev.*, **48** [43], 19 (1929).—An interesting patent on decorating ceramics, glass, and similar articles has been filed in the British Patent Office to the Deutsche Gold- und Silber-Scheideanstalt Vorm. Roessler, Germany. Ceramic, glass, etc., articles are decorated by first applying coatings of coloring solutions and then applying covering layers of substances which, on firing the articles, remain liquid, have a greater surface tension than the coloring layer underneath and contract to a net-like structure of which the lines or veins displace the adjacent coloring layer. The coloring solution may be of the luster type consisting of metals, such as gold, silver, etc., or metal compounds which are dissolved, colloidally if necessary, with the addition of resins, etc., in oils such as oil of turpentine or oil of lavender. The covering layer may consist of glycerine, ethylene-glycol, chloralhydrate, etc., in aqueous solution, aqueous alcoholic solution, etc. Gum arabic, tragacanth, gelatine, etc., may be added to the solution, and if desired, cane sugar. The covering layer may comprise: gum arabic, 40 g.; glycerine, 40 g.; sugar, 100 g.; alcohol, 300 g.; water, 520 g., and such solution may be applied by brushing, dipping, spraying, etc., to the dry or soft under-layer. The coated surface is allowed to stand for some time before firing, or if desired the article may be preheated. The covering layers may be provided with colors which are different from the color of the luster and in such cases the ground layer may comprise colorless resin-oil mixtures. E.P.R.

Incrustation of ceramic ware. THEODORE LENCHNER. *Pottery Gaz.*, **54** [626], 1275–76 (1929); reprinted from *Jour. Amer. Ceram. Soc.*, **12** [7], 498–501 (1929).—See also *Ceram. Abs.*, **8** [8], 555 (1929). E.J.V.

Technique of ceramic decoration. KARL JACOB. *Keram. Rundschau*, **35**, 204–207 (1927).—A review is given of methods of ceramic decoration, including descriptions of various methods of shaping clay bodies, the use of engobes, underglaze decorations, glazes, overglaze decorations, etc., and showing the applicability of certain methods to specific materials and for specific purposes. H.I.

Revival of the use of steel prints in making ceramic decorations. W. RIEBER. *Keramos*, **8** [10], T4, 335 (1929). F.P.H.

Manufacture of decalcomania paper. BILTZ-ASCHAFFENBURG. *Keramos*, **8** [10], T4, 339–40 (1929).—A description is given of the manufacture of decalcomania paper in Germany. The paper must be thin and at the same time very strong. Long-fibered material must be used to realize these two conditions in the same paper. F.P.H.

A cross-section through the color-printing industry. ANON. *Keramos*, **8** [10], T4, 343–47 (1929).—The history of a number of German corporations manufacturing decalcomania is given along with short descriptions of the present plants of these companies. F.P.H.

Linoleum block printed pottery. SADIE LOSHINSKY. *Pottery Gaz.*, **54** [626], 1266 (1929); reprinted from *Jour. Amer. Ceram. Soc.*, **12** [7], 502–504 (1928).—See also *Ceram. Abs.*, **8** [8], 555 (1929). E.J.V.

Decorated glass beads. W. HANNICH. *Keram. Rundschau*, **35**, 255–56 (1927).—Methods of producing and decorating glass beads in different German provinces are described. H.I.

Haircracking and exfoliation of faience. A. J. EDUARDS. *Sprechsaal*, **62** [14], 241–43 (1929).—It is explained that with permanent occurrence of above defects, the correction must be found in adjusting the coefficient of expansion of body and glaze, while with occasional occurrence the fault is to be laid to the manufacturing process as composition or preparation of raw materials, tempering, drying, firing, cooling. Where the coefficient of expansion of the body exceeds the one of the glaze, with cracking evidenced soon after the glost firing, the limit of elasticity of the glaze has been overstepped. Where the ware shows cracks after renewed firing during decorating, the limit of elasticity has also been over-reached because the coefficient of expansion of the body was greater than that of the glaze. This is due to the deformation of the glaze brought about during cooling under the pressure of the body through greater contraction of the latter, since it is at comparatively low temperature that the glaze assumes solid form and sufficient elastic strength. Partial heating and cooling will hasten the appearance of cracks when the coefficient of expansion of the body is larger as well as smaller than that of the glaze. Cracks due to excessive body coefficient and occurring before the hardening of the glaze, will show the edges rounded off. Special examples of cracking, not due to any variation in the coefficient of expansion, are those appearing occasionally below the glaze of decorated ware with chlorides, and those appearing occasionally on overglaze decorated ware, fired in a muffle kiln in cases where the color is applied. These cracks caused by unsuitable colorants can easily be detected and avoided. The appearance of exfoliation is due mainly to the same causes outlined. By increasing the quartz content (for increasing the coefficient of expansion of the body) we obtain fine quartz grains on the surface which are dissolved during the glost firing. Hereby the coefficient of expansion of the glaze is reduced approaching that of the body, thus avoiding cracks. If the difference in the two coefficients is too great, no correction is evidenced since the glaze dissolves quartz grains to a certain extent only. This explains why a thick glaze has a greater tendency to crack than a thin glaze. If it is advisable to change the glaze instead of the body, the coefficient of expansion of the glaze is diminished by an increase of SiO_2 or B_2O_3, but care must be taken not to render the glaze too sour since otherwise it will become turbid. By making changes in the firing, only improvements within narrow limits are possible. With a hard-fired body it is possible to increase the coefficient of expansion of the body without causing disruption of the edges (due to glaze pressure). To overcome exfoliation, the procedure is just the opposite; trying to effect a reduction in the coefficient of expansion of the body and avoiding such of the glaze. Since it is practically not possible to obtain equal coefficients, it is recommended to obtain the body coefficient larger than that of the glaze; if, however, this is in excess, exfoliation as well as cracks must be expected. An elastic glaze seems best and can be obtained by combining two frits of different properties as one with little lead and one with much lead. T.W.G.

Development of faience and majolica ceramics. TH. WOLFF. *Keram. Rundschau*, **35**, 259–61 (1927).—A brief history of the origin and development of art and technique in these industries. H.I.

Terrazzo for wall decorations. KENNETH REID. *Pencil Points*, **10** [7], 481–84 (1929).—The use of cloisonné terrazzo for wall decorations has a semblance of novelty. The terrazzo mixture is of marble chips and colored cement finished after application by grinding. Division outlines of the design parts are of brass strips soldered to a backing of galvanized wire netting. The color palette is limited to the kinds of marble but much may be done by blending colors of cement and such marbles as Red Antico, Red

and Yellow Verona, Blue Turquin, and Belgian Black. The possibilities of decoration have been further developed by inlaying in a molded cement or scagliola background. Illustrated. E.B.H.

American tile art. V. VALENTINE. *Architect*, **12** [4], 386–90 (1929).—A historical review of foreign and American floor and wall tile and their relationship is given in regard to color and design. T.W.G.

New ideas in color and design. ANON. *Ceram. Ind.*, **13** [2], 151 (1929). F.P.H.

Notes from abroad. ANON. *Studio*, **93** [386], 64–65 (1929).—Illustrations and descriptions are given of a pink pearl vase on an ivory stand, of 18th Century Chinese production, a combination of beauty of form and loveliness of color hard to surpass. A pair of *famille noir* bowls and Ch'ien Lung bowls are described. E.B.H.

Pottery shown in New York. RUTH CANFIELD. *Design*, **31** [3], 47–52 (1929).—Shown by American Designers' Gallery in New York is a group of pottery in the modern manner done by Henry Varnum Poor. Wall pockets of red clay and engobe majolica tile, a radiator cover of pierced tile decorated in the same manner, and a luncheon set complete the ensemble for the tulip-wood dining alcove. The platters, though oval with circular bases, are thrown on the potters' wheel. A transparent glaze is used throughout. E.B.H.

Brazilian art and the German ceramic industry. A. HERBORTH. *Keram. Rundschau*, **35**, 171–74 (1927).—A plea for the understanding of Brazilian tastes in art in order that German imports of ceramic ware, etc., into Brazil may be increased. A large number of primitive Brazilian motifs are illustrated. H.I.

Pottery and glass in New Zealand. ANON. *Rev. mat. constr. trav. pub.*, No. 232, p. 22B (1929). A.J.M.

PATENTS

Design for a plate. FREDERICK H. RHEAD. U. S. 79,101, July 30, 1929; URASABURO TOMITA. U. S. 79,111, July 30, 1929; MORTIMER PLUMER. U. S. 79,163, August 6, 1929; LOUISE PFUHL. U. S. 79,202, August 13, 1929 (reissues).

Design for a tumbler. BANKS D. BROWN. U. S. 79,126, August 6, 1929 (reissue).

Design for face brick. DOUGLAS F. STEVENS. U. S. 79,171, August 6, 1929 (reissue).

Design for a flower holder. R. GUY COWAN. U. S. 79,182, August 13, 1929; U. S. 79,183, August 13, 1929 (reissues).

Design for a bottle. OTTIS K. BROWN. U. S. 79,178, August 13, 1929 (reissue).

Design for a casserole. MELIK FINKLE. U. S. 79,133, August 6, 1929 (reissue).

Design for a covered dish. HAROLD TAYLOR ROBINSON. U. S. 78,987, July 16, 1929 (reissue).

Design for a cup. FREDERICK H. RHEAD. U. S. 79,102, July 30, 1929 (reissue).

Design for a dish. FREDERICK H. RHEAD. U. S. 79,100, July 30, 1929 (reissue).

Tile-enamel process. GEORGE W. KRICK. U. S. 1,724,206, August 13, 1929. The method of coloring tile by means of a stencil which consists in using a stencil made of flexible, elastic, non-absorbent outer layers and a non-elastic, absorbent inner layer of a certain thickness to allow an application of a comparatively heavy layer of coloring to simulate hand-decorating, dampening the underside of such a stencil to assure an adherence of every part of the stencil to the uneven top surface of a tile, and then applying the coloring material in an exceedingly damp state through the stencil by building up the coloring material to various thicknesses to simulate hand-decorating and at the same time utilizing the excess dampness of the coloring material to draw and hold the stencil to the absorbent surface of the tile.

Cement, Lime, and Plaster

Anhydrite as a retarder of Portland cements. C. R. PLATZMANN. *Tonind.-Ztg.*, **53** [4], 59–61 (1929).—This was previously abstracted from *Pit and Quarry;* see *Ceram. Abs.*, **8** [8], 559 (1929). F.P.H.

Cement and the chemical industry. HANS KÜHL. *Tonind.-Ztg.*, **52** [91], 1817–20 (1928); *Rock Prod.*, **32** [16], 94 (1929).—The hardening energy of Portland cement has recently been increased by admixtures of ground "catalyzers" after the clinkering. The initial strength of a cement was increased by the addition of about 2% of calcium bromide, from 58 to 238 kg./cm². Data for building up a scientific system in respect to the effect of "catalyzers" are still lacking, for the individual cements are so different. The lime combinations in the silicate cements are dibasic and tribasic, and in the alumina cements essentially only monobasic. The alumina cement is more resistant to chemical aggression, particularly sulphate waters, than any other cement. More coöperation between the iron industry and the slag consumers is being effected especially in times of economic depression in respect to the production of iron Portland and slag cements. In Leverkusen the manufacture of sulphuric acid from gypsum has been started with Portland cement as a by-product. A raw mix of gypsum and clay is calcined which yields sulphurous acid for manufacturing sulphuric acid and a residue of about the composition of Portland cement clinker. F.P.H.

Acid-resistant cement. ANON. *Brass World*, **25** [3], 59 (1929).—The "U. S. Standard," the makers claim, is fully resistant to corrosion by acids, alkalis, and other fluids or gases which are commonly considered to be corrosive agents, with the exception of hydrofluoric acid. E.P.R.

Testing of small samples of cement. HANS KÜHL. *Tonind.-Ztg.*, **53** [19], 374–77 (1929). F.P.H.

Composition of the Portland cement clinker. E. JAENECKE. *Zement*, **18** [10], 288–92 (1929); *Rock Prod.*, **32** [15], 86 (1929).—The effects of variation of the composition of various structural constituents on the quality of the cements are investigated. F.P.H.

Relation of quality to cost of production of Portland cement. EDUARDO TAYLOR. *Rock Prod.*, **32** [16], 64–65 (1929). F.P.H.

Patent history of lime. JOSEPH ROSSMAN. *Rock Prod.*, **32** [16], 66–72 (1929).—The patent history of lime is prolific. There are about 150 more patents than those abstracted here. In this article R. has confined his attention only to process patents in the art of making quicklime. It will be noted that most of them are intended to give greater fuel or thermal efficiency. It has long been recognized that lime calcining can be improved. The same holds true today. F.P.H.

Utilization of heat in lime-shaft kiln. KUTSCHERA. *Tonind.-Ztg.*, **53** [4], 65–67 (1929).—Heat balances for various types of lime kilns are given and their thermal efficiencies compared. F.P.H.

Alite. HANS KÜHL. *Zement*, **17** [35], 1303–1305 (1928); *Rock Prod.*, **32** [15], 86 (1929).—According to K., the alite is a series of mixtures of tricalcium silicate and Jaeneckeit or of tricalcium silicate and (hypothetical) dicalcium aluminate. F.P.H.

Enamels

Wet-process leadless cast-iron enamels. A. I. ANDREWS AND C. H. COMMONS. *Jour. Amer. Ceram. Soc.*, **12** [9], 557–65 (1929).—Several promising compositions have been developed in the laboratory in an extensive investigation for the development of satisfactory leadless wet-process cast-iron enamels. Each series investigated is described. It is concluded that such an enamel is feasible as several fair enamel and one

good one were developed during the investigation. Best results were obtained when the enamels were washed and although this is impractical in plant practice it is hoped that an insoluble frit may be obtained thus eliminating the necessity for washing in order to obtain the required gloss.

Method for testing the fineness of porcelain enamels. H. L. COOK. *Jour. Amer. Ceram. Soc.*, **12** [9], 566–69 (1929).—The sieve-shaker method of testing is described and recommended for use as a means of testing the fineness of porcelain enamels. The initial expense of equipment is offset by the economy of having the enamels leave the mill room in proper condition.

Use of antimony-bearing opacifiers in the enamel industry. H. HAUPT AND G. POPP. *Keram. Rundschau*, **35,** 221–23 (1927).—Experiments are described in which two antimony-containing opacifiers bearing the trade names "Leukonin" and "Timonox" were treated with boiling solutions of tartaric acid, acetic acid, and hard water to determine the amounts of pentavalent and of trivalent antimony dissolved. It is concluded that the amounts of trivalent antimony dissolved from enameled vessels using this particular brand of "Leukonin" are insufficient to be dangerous to the health while the amounts of trivalent antimony dissolved from vessels enameled with the particular brand of "Timonox" are so great that such vessels are unsafe for use as household cooking utensils. H.I.

A study of adherence of ground coats to sheet steel. C. D. CLAWSON. *Ceram. Ind.*, **13** [2], 164–66 (1929).—The purpose of this investigation was not to measure the adherence in terms of pounds per square inch, but rather to study it at the source. To learn the reason why ground coat adheres so firmly to metal and what factors affect this property. The study consisted of a group of photomicrographs of three different types of enamels applied on low carbon steel and ingot iron. The photographs accompanying this article were made at a magnification of 1000 diameters. For many years the use of a nickel bath has been known to develop adherence and reduce tendency to fish-scale. The results of this treatment are unquestionable but the skill and experience required in applying this nickel coating properly makes its use undesirable in the majority of plants. Since it is known to improve the adherence of the enamel to the metal, a photomicrographic study was made of samples treated in this manner. The nickel coating was applied with the following procedure: The samples were pickled and rinsed in clear water in the usual manner. They were then immersed in a bath of nickel sulphate 9% Bé, at 160°F for about 8 min. The electrolytic action of the nickel salts produces a thin film of nickel on the ware. The samples were then neutralized, dried, and the ground coats applied as before. The photographs shown clearly demonstrate the effectiveness of the nickel film in developing adherence. F.P.H.

Copper etching for enameling. ADOLF STADLER. *Keram. Rundschau*, **35,** 209 (1927).—The process of etching designs on metal articles to be enameled, either by direct etching or by re-impression, is described. H.I.

Effect of nitrogen in iron and steel. V. N. SVECHNICOV. *Blast Fur. Steel Plant*, **17** [7], 1021–26 (1929).—A Russian metallurgist gives a review of investigations made on the bad effects of nitrogen content on the physical properties of steel. Sources of nitrogen are reviewed. F.P.H.

Diffusion of iron oxide from slag to metal in open-hearth process. C. H. HERTY, JR. *Mining and Met.*, **10** [272], 389–90 (1929).—The theory of the diffusion of FeO from slag to metal is discussed and illustrated with data. F.P.H.

Sands for oil-sand cores. RUDOLPH STOTZ. *Refrac. Jour.*, **4** [46], 329–30 (1929); *Die Giesserei*, No. 38 (1928).—Requirements to be looked for in "quartz sands" for oil-sand cores are discussed. Core sands can be divided into two main groups: (1) river and sea sands, termed "sharp" sands, which are almost pure quartz and cannot

be used without artificial binder, and (2) molding sands, dry sand and loam with a natural content of clay as binder. S. confines himself to consideration of the sands of the first group. The benefits compared with ordinary sand cores center in the ability to produce the most complicated cored castings while keeping cleaning costs to a minimum, and at the same time obtaining a very clean finish. The requirements called for from any core sand are plasticity, refractoriness, gas permeability, and strength. Demands in the way of plasticity are in certain cases dependent upon the method of preparing the core. The plasticity is obtained by suitable admixture of core oil to the sand. The refractory qualities of oil-sand cores are not, in the case of large cores, of massive castings, as good as those of cores containing clay, as, owing to the greater incandescent effect of the larger masses of iron in the thicker castings, the organic binder is fired before solidification of the iron is complete, and the core thus loses its strength too early. Although clay is highly refractory, there appears with increasing clay contents, the disadvantage of hard cores with consequent increased cleaning costs. Sand for oil cores should consist of silica of the highest possible purity possessing a melting point of over 1700°C. It is important that the sand should contain no lime or alkalis as these lower the fusion point of the quartz and cause the sand to be fired onto the casting. The presence of calcium carbonate also may lead to blowholes in the castings due to the carbonic-acid gas set free in the sand on pouring, while a content of alkali would saponify a portion of the core oil. The gas permeability of cores is very greatly influenced by the shape, size, and uniformity of the grains. With decreasing grain size the permeability naturally becomes less, but if a sand is of a mainly coarse nature with large grains the presence of a certain proportion of fine grains may block up the interspaces between the large grains and bring about extremely poor permeability. The grain size, with oil-sand cores, should not exceed 0.5 mm., and is best kept at 0.2 to 0.5 mm. The strength of the oil-sand cores is also very strongly influenced by the water content of the sand, and systematic experiments proved the value of the practice of drying the silica sand before mixing. After drying well, the sand is moistened with a definite quantity of water which has been found from experience is best suited to the particular type of castings to be turned out. For every binding agent a definite drying temperature and drying period have to be adhered to. E.P.R.

Low-pressure sandblast. ANON. *Brass World*, **25** [6], 145 (1929).—There are two kinds of sandblasting. One which uses high-pressure air (from 5 lbs. per sq. in. up to and even exceeding 100 lbs. pressure). The other uses air at less that 5 lbs. pressure. Most castings can be improved in appearance by the use of low-pressure sandblasting. This process accentuates the natural color of castings and where they are to be electroplated, painted, enameled, or otherwise finished the sandblast produces a mat finish or surface to which the plate, paint, or enamel will readily adhere. E.P.R.

Pickling house. W. SCHEFFEL. *Keram. Rundschau*, **35**, 207–208 (1927).—The relative merits of wood (either treated or untreated), sandstone, Solenhofen stone, and remelted basalt for the vats and floors in pickling rooms of enameling plants are considered. Despite the rather high cost, slabs of basalt made by melting, casting in molds, and annealing basalt rock are considered the best. H.I.

Removal of acid fumes from pickling rooms. JAMES SILBERSTEIN. *Brass World*, **25** [3], 54 (1929).—Installations are shown and discussed. E.P.R.

Enameling metal. P. W. HOPKINS. *Amer. Machinist*, **71** [2], 49–52 (1929).—The process of enameling cast-iron and sheet-iron parts at the plant of the Geo. D. Roper Corp. are described and illustrated. Cast-iron parts are sandblasted and stored in heated store rooms, while sheet-metal parts are chemically cleaned. T.W.G.

Enameling stoves. ANON. *Emaillewaren. Ind.*, **6** [22], 175–77 (1929). T.W.G.

Enameling agent containing antimony. T. UCHIDA AND K. ARIKI. *Repts. Imp. Ind. Research Inst.* [Japan], **9** [1], 1–33 (1928).—Various combinations of enameling agent, containing various amounts of (*a*) $Sb_2O_3 + KNO_3$ (2:3), (*b*) fluorspar, (*c*) cryolite, (*d*) SiO_2, (*e*) feldspar, (*f*) Na_2O, and (*g*) borax were studied for luster, degree of emulsification, shrinkage, bubbles, and cracks produced in the product after baking at about 800°. The chemical composition of these combinations was calculated from the amounts of ingredients used in the mixture and is given in a table. Results: *Luster:* samples containing (*a*) and (*c*) were inferior to those containing (*b*). The ones containing much of the basic constituents, *i.e.*, (*f*) and (*e*) gave poor luster. *Emulsification:* The influence of composition on the degree of emulsification was very slight. Samples containing much (*a*) gave products of low quality while ones containing (*a*), (*b*), and (*c*) together gave the best results. Samples containing excess of (*f*) and (*g*) gave very poor results, and the ones containing basic constituents gave poor emulsification, which is contrary to the usual conception. *Shrinkage:* When (*a*), (*b*), and (*c*) were present together, good products were obtained. With increase in acid constituents products of lower grade were obtained. *Bubbles:* With increase in basic constituents inferior products resulted. *Cracks:* An increase in (*c*) gave more cracks, while an increase in basic constituent seemed to improve the products. (*C.A.*)

Study of enameling agent. T. UCHIDA. *Repts. Imp. Ind. Research Inst.* [Japan], **9** [4], 1–381 (1928).—By combining various proportions of Na_2CO_3, K_2CO_3, orthoclase, H_3BO_3, Zn white, $CaCO_3$, fluorspar, MgO, Al_2O_3, quartz, clay, feldspar, Na_2SiF_6, Co_2O_3, and saltpeter, about 2000 specimens of frit were prepared and studied when applied on Cu, cast Fe, or steel plates. Examination was made of luster, emulsification, shrinkage, amount of bubbles and cracks, and the degree of adhesion. The influence of composition on quality is discussed. The relation is complicated and no hard and fast rule can be given. The standard composition of an enameling agent can be expressed by 1.5 R_2O, 1 RO, 0.5 B_2O_3, 3 SiO_2 (where R = a metallic element). About 250 pp. of tables and numerous photomicrographs are presented. (*C.A.*)

PATENT

Enamels. I. KREIDL. Brit. 313,411, August 8, 1929. A method of clouding enamels consists in using a clouding agent of the kind which acts by liberation of gas, together with one of the usual clouding agents which serves as a distributor for the gas bubbles. By this method, sufficient density is obtained with less material than is usually required when tin oxide is used alone. An enamel which is free from or contains only a small amount of fluorine, or one which has become clear through overheating, may be clouded by a mixture of ammonium oxalate and tin oxide.

Glass

Electrical conductivity and constitution of glass. A. SMEKAL. *Keram. Rundschau*, **37** [21], 361–64 (1929); *Glass Ind.*, **10** [8], 196 (1929).—After an introductory review of the particularities of the states of glass, the analysis of the interdependence between temperature and electric conductivity of glasses was utilized to obtain insight into their molecular structure, which so far is but very slightly known. The knowledge of the mechanism of the conduction of electricity in crystallized non-metallic substances is applied to the state of glass. In agreement with experience it appears that only the ions of the alkali metals, especially sodium, take part in the conduction of electricity in glass. The ions of the alkaline-earth metals, calcium, and barium, and of the other chemical elements present in glass, show a much stronger chemical combination than the alkali metals, so that they are not agitated by the electric current. Their presence in the glass, however, has a considerable influence on the mobility of the sodium ions.

E.g., from the properties of the alkaline-earth atoms it follows that glasses rich in lime must hamper the movement of sodium ions more strongly than those rich in barium, and experience actually proves that lime glasses are much better insulators than barite glasses. On the basis of the experience obtained with crystals, it is known that the strength of the linkage of electrically agitated particles can be considerably reduced locally by high internal stress. The conspicuous difference in the inter-dependence between temperature and electric conductivity in tough and brittle glass, rests exactly on a difference in strength of linkage of the sodium ions which can be expressed numerically. As the linkage strength in brittle glass is a considerably lower one, it may be concluded that brittle glass is subject to high molecular stresses acting within minute empty spaces which are too small to be detected under the microscope. This particularity which is entirely different from the behavior of the crystallized substances, appears not only to cause the high brittleness of "brittle" glass, but also becomes manifest through a pronounced reduction of the sensitiveness to temperature of the density and also of the refraction of the glass; experience shows that the expected changes in these properties during transition from "tough" to "brittle" glass occur abruptly and with great sharpness at the "point of transformation." In addition to the high inner stresses mentioned, brittle glass can also be given through chilling at high temperature inner stresses which can be detected by optical means. These stresses must cause a further decrease in linkage strength of the sodium ions in the glass and consequently influence its conductivity. In fact, the conduction of electricity in "stressed" glass is found to be higher, exactly in the direction expected, than in "stress-free" glass. By means of a prolonged and continuous flow of current, it should be possible to remove the most weakly linked sodium ions of the "stressed" glass and thus produce a gradual relief of its tension. This conclusion has also been confirmed by experimentation.

E.J.V.

Introduction of magnesia into glass batches. H. KÜHL. *Glasindustrie*, **36**, 31 (1928).—K. referred to a brochure in which he had pointed out the favorable influence of 0.90–2.2% MgO in a glass in improving the behavior of the glass toward sudden changes of temperature. He had found that batch II was an improvement on batch I for the making of chemical glassware. A good useful lime-free chemical glassware batch was No. III. The batch V melted down as well as IV from which it was derived:

	I	II	III		IV	V
Martinsroda sand			750			
Hohenbocka sand	300	300	750		74.65	74.65
Ground marble	28.2	22		Limespar	12.65	5.61
Magnesia		2.5	15	Dolomite		7.00
Barium nitrate	20	20	60	Alumina	1.55	1.55
Borax (anhydrous)	18	18	150			
Soda ash	65	65	45		18.5	18.5
Potash	40	40	85		6.5	6.5
Zinc oxide	15	15	30			
Meisner clay	15	15				
Arsenic	2	2	20			
Sodium fluosilicate			25			
Potash niter			30			
Antimony oxide			60			

The purest dolomite met hitherto in German glassworks by K. was the Rothenzechau dolomite supplied by Messrs. Dobermann & Co. According to the latter firm, the iron oxide content varied between 0.2075 and 0.2105% Fe_2O_3. (*J.S.G.T.*)

Characteristics of crystallized silicates and their glasses as studied by V. M. Goldschmidt. W. EITEL. *Keram. Rundschau*, **35**, 220–21 (1927).—Efforts of Goldschmidt

and others to study the properties and characteristics of silicates by substituting for the components of silicates others with similar atomic configurations, crystallographic, and optical properties but with lower melting points and lower viscosities are described. The possibility of finding improved technical products such as better glasses is suggested. H.I.

Devitrification phenomena. V. GROSSMANN. *Keram. Rundschau*, **37** [21], 361–64 (1929); *Glass Ind.*, **10** [8], 195 (1929).—The separation of crystals from an amorphous mass of glass is a process which must be discussed both from the chemical and from the physical point of view. The conditions, under which our most commonly used kind of glass, soda-lime-silica glass, becomes devitrified, have long been sufficiently known. Percentage composition and working temperature can be selected through knowledge of the ranges of stability of the individual phases of the batch in such a way as to create in advance the least favorable nutrient medium for the formation of crystals. The extent, to which the chemical composition of a glass is connected with its devitrification capacity, is shown by a number of recent investigations of very different kinds of glass, with special consideration of special glasses containing lead and boric acid. In this case also, both the theorist and the practical man are interested in a review of those whose composition, by keeping the given temperature conditions, gives the minimum ability to devitrify. A devitrification phenomenon which cannot be explained from a chemical viewpoint is the increased separation of crystals at the glass surfaces, which formation is intensified by the presence of fractures. Purely physical considerations must be used here to find an explanation. The formation of crystal nuclei, whose origin may be explained as being due to the collision of several molecules, is a function of the potential energy of the molecules of the individual layers. The activity of the surface layers far exceeds that of the inner layers, as by contraction ranges of activity of the individual molecules draw closer together. Assuming an appropriate heat treatment, a "typical boundary line" appears for each kind of glass, on the basis of surface devitrification indicating the region of beginning crystallization. This, however, again makes possible reactions on the degree of saturation of the dissolved silica in the metallic silicate concerned, which may lead to the assumption of the existence of disilicates in the glass. This conception also finds support in the latest investigations upon silicic hydroxide, which have shown that from supercooled batches of certain silicates, silicic hydroxides can be obtained as chemical compounds which differ physically from those obtained from the corresponding crystals only by their extraordinarily fine structure. Expanding the idea of supercooled batches, glasses may therefore be conceived, according to Tammann, as phases which have already reached a certain degree of arrangement and represent a primitive condition of crystalline distribution of the matter. E.J.V.

Devitrification of glass. P. VILLARD. *Compt. rend.*, **188**, 969–72 (1929).—The devitrification of glass tubing produced by heating the glass in a blow-pipe or blast lamp is due to the removal of alkalis by the action of atomic H. Pure hydrogen, oxygen, or CO_2 passed through a tube heated from 750 to 950°C will not attack the glass, but if hydrogen containing a small amount of oxygen is passed through the tube a luminous yellow ring will be formed at the heated portion and the interior of the tube will be corroded at the edge of the ring. If the gas issuing from the end of the tube is lighted it will burn with a yellow flame. The same result is obtained if pure hydrogen is passed through a glass tube heated to about 800° in which platinum wires are placed so that a spark discharge takes place between the wires. H.I.

Volatility of selenium and its compounds. J. B. KRAK. *Glass Ind.*, **10** [8], 181–84 (1929); reprinted from *Jour. Amer. Ceram. Soc.*, **12** [8], 530–37 (1929).—See also *Ceram. Abs.*, **8** [9], 638 (1929). E.J.V.

Purifying glass. H. KALSING. *Keram. Rundschau*, **37** [21], 361–64 (1929); *Glass Ind.*, **10** [8], 195 (1929).—Experiments studying the influence of different purifying agents, different cullet additions, and for individual purifying agents, also the influence of temperature and time on the refinement were reported on. The experiments were carried out by keeping mixtures with systematically varied additions of purifying agents at definite temperatures for definite periods of time. In the controlling experiments, the periods of time were chosen in such a way that, in the case of addition of the most suitable purifying agent, the batch was approximately clear. The number of bubbles in the molten glass was taken as a basis for judging the degree of purification. Parallel experiments were carried out with quantities of 10 cc. in platinum furnaces and in 300 kg. pots in a factory furnace. The experiments in factory pots and in the laboratory are in fair agreement. The purifying agents used were potassium nitrate; arsenic; potassium nitrate and arsenic; potassium nitrate with additions of sodium sulphate; sodium sulphate alone and when used in larger quantities with differently proportioned additions of charcoal; charcoal alone; ammonium sulphate, chloride, and nitrate; and sodium chloride. A medium hard lime-soda glass served as the basic glass; in every case the purifying agents were added to the mixture. In this way the most favorable addition was determined for each of the purifying agents. Temperature and time have great influence on the purification, especially temperature. The investigation of the mixture containing cullet showed that an increased addition of cullet greatly increased the number of bubbles, also the bubbles become smaller as the amount of cullet increases, and therefore escape less easily. Suitable additions of purifying agents, such as sulphate, reduce the number of bubbles in cu. cm. glass also. It should be observed, however, that the addition of purifying agents to the mixture must vary in accordance with the cullet content. For the mixtures used with additions of sulphate the refinement is always best, at least for a cullet content up to 70%, when 0.5% Na_2O of the total quantity is added to the mixture in form of sulphate. E.J.V.

Glauber's salt as a refining medium for glass melts. ERICH FELSNER. *Keram. Rundschau*, **35**, 239–40 (1927).—The advantages of Glauber's salt for this purpose are stated. H.I.

Basic oxides and glass properties. N. KREIDL. *Keram. Rundschau*, **37** [21], 361–64 (1929); *Glass Ind.*, **10** [8], 196–97 (1929).—The first requirements of the glass industry have been to expand its simple composition to the extent in which the fields of application of its material have enlarged, and the quality requirements specialized. This has been done with respect to colored glasses, a problem which was first an empirical one. Other requirements followed which could no longer be mastered empirically. If, for example, the splendid successes of the optical glass industry first became the incentive to thorough scientific investigation of certain changes in properties, this young science was, conversely, soon able to seize most chemical elements for glass production. This may be demonstrated in the periodic system. Contrasted to a few substances that do not form glass, chlorine, bromine, iodine, and mercury, we have the main glass formers and those elements which themselves, or whose compounds, are used for coloring and discoloring, rendering turbid, permeability to X-rays, permeability to ultraviolet rays, viscosity, resistance, expansion, and purifying action. The leading thought in the scientific work of the last decade has been a systematic review of the quantitative effect of all additions. The first step was the additive Winklemann-Schott factors. The properties, however, do not change in linear relation with the additions so that the effect of the substances must be investigated and tabulated by steps. Gehlhoff's investigations were pioneer work in this respect and made it possible to demonstrate the desired method by his handling of the mechanical properties. Particularly interesting for the working of glass is the effect of oxides on viscosity and expansion due to

heat. The physical expression of the so-called "shortness" and "length" of glass is the change of temperature necessary to bring a glass from a given lower viscosity to a given higher one. This can be shown graphically for two definite degrees of toughness lying in the vicinity of the actual working range on a Gehlhoff diagram. Magnesium has a special interest in this respect because of use in the machine glass industry and to the fact that an amphoteric nature of it is possible. The coefficient of expansion can rather be established additively. The correction of the values found by Winklemann and Schott, made last year by English and Turner, has in the meantime been confirmed in Russia. From a practical point of view, the following chief difficulties interfere with accuracy in calculations: (1) dependence of the thermal expansion on the melting temperature; (2) on the degree of turbidity, especially with regard to the kryolith factor 7.4 calculated by Havas; (3) in a strong degree, on the cooling. The latter point, which is especially important for flashed glass, is utilized empirically for the subsequent equalization of originally different expansion coefficients through varied annealing. E.J.V.

Colors for painting glass. K. KILLER. *Keram. Rundschau*, **37** [21], 361–64 (1929); *Glass. Ind.*, **10** [8], 196 (1929).—The glass region of northern Bohemia has been very intensively occupied during many centuries in the manufacture of painted glass. The industry, which manufactures the colors, has from the beginning adapted itself to the needs of glass painting and decorating, and has continuously tried to produce new effects through new colors and combinations of colors. The literature on colors for glass painting is very meager and what is found in this literature is only partly correct. This subject was therefore briefly reviewed from the chemical point of view and some recommendations made upon the manufacture of enamels, fluxes, and the coloring materials. Mention was also made of the complicated conditions which result when several colors that mutually react and then give trouble during annealing must be painted over one another. The oils used in painting also play an important part and their purity and composition are of considerable influence. The subdivision of colors into opaque and transparent enamel colors, flat, body, and opaque colors, lusters, etc., was treated. The manufacture of the coloring substances and the behavior of the latter toward enamel or flux was also touched upon. Finally, the firing of the colors in the ordinary pot muffles, as is usual in northern Bohemia, was explained and experiments were also discussed which have been made in recent years with an electric muffle. Very good results have been obtained. E.J.V.

Color and its applications. L. C. MARTIN. *Ill. Eng.*, **22**, 33 (1929).—The influence of color on the acuteness of vision was discussed, and Exners' curves showing how the speed of vision was increased by increase of brightness were reproduced. Color measurement was dealt with and a new apparatus for this purpose was described. This apparatus used spectral primaries, red, blue, and green, and any combination of these could be desaturated to any desired extent so that it was possible to watch and measure any shade. Physical photometry, by the use of light-sensitive cells, was mentioned and curves were given of the sensitiveness of a cadmium cell fitted with a Uviol glass window to ultra-violet rays. Some applications of colored light were mentioned including the use of special "daylight blue" glass screens to produce a light suitable for color matching purposes and for rendering artificial light less tiring to the eyes. (*J.S.G.T.*)

Measurement of the viscosity of glass at high temperatures by the rotating cylinder viscosimeter. R. F. PROCTOR AND R. W. DOUGLAS. *Glass Ind.*, **10** [8], 193 (1929).—The viscosity of glass was measured using the rotating cylinder method. A full description of the apparatus used was given. Calibration at low viscosities had been achieved by the use of golden syrup, while pitch was employed in the use of high viscosity. Contrary to E. W. Washburn's experience, the calibration factor for a rotating

cylinder viscosimeter was independent of the viscosity, at least over the range 10^3 to 10^8 c.g.s. units. From results of experiments made with sodium silicates, it was concluded that the variation found by Washburn in his calibration factor was due to the formation of a skin on the surface of the liquids used. Using a glass of composition similar to those used by the earlier workers, S. English, V. H. Stott, and E. W. Washburn, determinations were made on the viscosity over a considerable range of temperatures. A reduction in the accuracy of their results was noted around about 950 to 1000°C similar to that experienced previously by Stott. It was shown that all the published data (including Washburn's work corrected by the authors) were in reasonable agreement when allowance was made for variations in the compositions of the glasses used. E.J.V.

Study of the thermal expansion of glass up to the softening temperature. W. E. S. TURNER AND F. WINKS. *Glass Ind.*, **10** [8], 193 (1929).—A comprehensive survey was made of the linear expansion of different types of glass from room temperature up to the softening point. It was shown that careful attention must be paid to the physical condition of the sample of glass under test if comparable results are to be obtained. A wide range of glasses was examined including the following series: soda-silica, soda-lime-silica, soda-lime-silica colored with cobalt oxide, soda-barium oxide, silica, sodium-lead oxide-silica, soda-iron oxide-silica, potash-lead oxide-silica, and a number of glasses of more complex character. The curves obtained by plotting the increase in length per unit length against temperature showed two very marked changes in direction on two points described as the lower critical and the upper critical point, the temperatures corresponding to these marking the limit of the so-called annealing range. The extent of this range and the slope of the curve varied considerably with the composition. It was shown that over the temperature range between room temperature and the lower critical point, the curve indicating the relationship between increase in length and temperature was, in most cases, not a straight line, but was made up of two, three, or more sections, each of which was precisely linear. The points of inflection of the curves in this lower temperature range were closely the same for all glasses built up according to a common general formula. The first inflection point occurred between 120 and 150, the second at about 250, and where a third break occurred, at about 350. These breaks did not occur in the potash-lead oxide-silica glass examined, and were scarcely existent in the soda-lime-silica glasses containing small amounts of cobalt oxide. Glasses containing boric oxide as a constituent were particularly difficult subjects of test, and showed themselves very sensitive to heat treatment. When the linear expansions of the glasses were plotted against the percentage values of the distinguishing oxide present in the glasses for the temperature ranges 0 to 120° or 150°, 150 to 250° and 250° (the lower critical temperature) it was found that the points lay on a series of straight lines. The relationship between the expansion and percentage of oxide was, therefore, linear over these temperature intervals. Factors were obtained from these graphs for each oxide, and by their use it was possible to calculate the linear expansion of glasses up to the critical temperature. E.J.V.

Projection of polarization phenomena in glasses. R. ETTENREICH. *Keram. Rundschau*, **37** [21], 361–64 (1929); *Glass Ind.*, **10** [8], 196 (1929).—In order to test the condition of stress of glasses, use has long been made of their examination in polarized light by subjective observation. In objective observation, *i.e.*, by using a projection system, more details can be distinguished but a lens effect occurs which greatly increases the difficulty of easy application. This drawback may be completely eliminated by dipping the pieces of glass to be examined in a liquid having the same refractive index. From the difference in dispersion between liquid and glass on one hand, and the differently cooled portions of the piece under examination on the other, a colored picture

results in combination with the polarization effect which gives an excellent insight into the fine structure of the stresses. E.J.V.

Photo-elastic properties of glass. F. C. HARRIS. *Glass Ind.*, **10** [8], 193 (1929).—H. briefly reviewed the stress-optical properties of glass, dealing with the effect on the stress-optical coefficient of chemical composition and temperature. The effect of composition had been investigated by F. Pockels in 1902, using a series of lead oxide-containing glasses. The value of the stress-optical coefficient was found to decrease as the PbO percentage content increased, becoming zero for a glass containing about 75% PbO, and being negative for 80% PbO. These results were confirmed by L. N. G. Filon, who worked with PbO values beyond 80%. Further, the coefficient was found to be increased by the addition of boric oxide, and decreased by potassium oxide, but the effect of these oxides was small compared with that of lead oxide. Both Pockels and Filon had investigated the dispersion of double refraction in glasses, and the glasses appeared to fall into two series. The effect of age and previous history of the glass might account for the differences in behavior. E.J.V.

The electrical charges produced on glass by cathode rays, and their practical use. P. SELENYI. *Z. tech. Physik*, **9**, 451 (1928).—Electrons of velocity 6 to 12 k.V., impinging on a charge-free glass surface, were there almost quantitatively intercepted and remained held there at the highest vacuum (the ionization decreasing). These phenomena were observed by the use of a new kind of cathode, oscillograph-tube. The cathode rays fell on the inner surface of the glass tube and they produced curves traced by electric charges which were rendered visible by coating the outer glass surface with lead sulphide. Two types of tube were described: (1) the electrons were in an accelerating electric field until close to the interception surface, in order that the positive ions might be kept distinct from this surface; (2) the cathode rays were accelerated, as usual, for a short distance and then left in a field-free space. With a magnetic field of attraction due to a three-phase current of 50 cycles per second, figures were produced like a single branch of a sine curve for a 500-cycle-per-second machine. The velocity records up to 4000 cm. per second at a cathode ray intensity of 2μ A. showed increases of velocity proportional to the ray intensity. Under certain conditions the intercepted electrons in such tubes produced peculiar electrical figures, and observations were made on these. (*J.S.G.T.*)

Measuring the index of refraction of glass for ultra-violet ray radiation. C. FARBY AND J. BAROT. *Rev. d'Optique*, **7**, 429 (1928).—The authors devised a method to determine the refractive index of a transparent substance for rays in the ultra-violet region which made use of a 60° prism of normal type, and gave on a photographic plate a record from which calculations for the various wave-lengths could be made. A feature of the method was the use of an ordinary Jobin-Yvon goniometer with quartz-fluorite lenses, in which by interchanging the slit and telescope ocular, the ordinary collimator was used as an independently mounted telescope, and the ordinary telescope became a collimator capable of being swung about the axis of the table. The camera was mounted separately. With different collimator settings of measured angular displacement, a series of exposures were made on the same plate as the spectrum exposure plate, masking the center of the slit. This gave a number of reference points of known angular separation leading to a computation of the deviations for the various spectral lines. All errors considered, the accuracy obtainable was of the order of 2 to 3 units in the 5th place. This had been verified by comparison of a given (mercury-green) ray both visually and photographically. (*J.S.G.T.*)

Approximate method of calculating the absorption coefficient of optical glasses. A. A. GERSCHON. *Z. tech. Physik*, **10**, 18 (1929).—A simple formula was developed which gave with an error of approximately 1%, the absorption coefficient, K, of a glass

in terms of the length of specimen, readings of polarization photometer, and a constant depending on the refractive index of the glass. (*J.S.G.T.*)

Annealing glass with electric heat. A. N. Otis. *Glass Ind.*, **10** [8], 186–88 (1929).—The temperature required for annealing is about 1000°F, varying somewhat with the kind and size of ware. Fuel-fired leers are designed with a fire box at the entrance end, the gases from which pass along the chamber or through muffle passages through uptakes to a stack. It is difficult to secure and maintain accurate temperatures along the chamber, and the ware is sometimes discolored by deposits from the furnace gases. Scientists have determined that strains can be relieved in a very short time if exactly the correct temperature can be secured, but a much longer time is required if the temperature is approximate or not subject to accurate control. With electrically-heated leers, the heaters are distributed along the chamber and divided into sections or zones, each with automatic temperature control, so that any desired temperature characteristic can be secured and automatically maintained. The characteristic can be readily changed for different kinds of sizes of ware by adjustment of the instrument settings if the atmosphere is always clean and sterile. Control of the temperature curve permits a shorter annealing time which in turn permits the use of shorter leers, saving considerably in floor space. Electrically-heated leers are in use for annealing bottles, packing jars, large 5-gallon water bottles, multiple-compartment jars for storage batteries, and for decorating table glassware. Other types of furnaces are in use for annealing X-ray and vacuum tube bulbs, miniature lamp bulbs, and lenses and prisms of optical glass for cameras and binoculars. Ware having heavy sections, like 5-gallon water bottles, is quite difficult to anneal, and the success of the electric leer in work of this kind is a distinct achievement. Various different installations are described. E.J.V.

Mechanical heat control of glass furnaces. W. Friedmann. *Keram. Rundschau*, **37** [21], 361–64 (1929); *Glass Ind.*, **10** [8], 194–95 (1929).—Method of heating furnaces in glass works influences not only the fuel consumption but also decidedly the quantity and quality of the glass produced. The heat control of glass furnaces heated by producer gas consists primarily in the adjustment of the following five items: (1) air for the generation of the gas, (2) steam added, (3) fresh gas, (4) air from combustion, and (5) flue gas. The quantities of these are to be regulated in such a way that the necessary quantity of heat to be supplied to the furnace as well as definite values for the various conditions, *e.g.*, the composition of the gas, the gas pressure in front of the gas regulator, the temperature and pressure in the heating chamber of the furnace, the nature of the flame, etc., be maintained with a view to the technical requirements of operating, heating, and glass technology. Any intentional change in one of the five mediums requires adjustment of the other media in order to maintain the required values of the factors; unintentional disturbances of individual components of a condition must be compensated. Any regulation by hand is carried out slowly and inaccurately, even if skilled and conscientious workmen attend the furnace, and usually leads to over-regulation and fluctuations. Equipment of the furnaces with measuring instruments may, if suitably arranged, facilitate heat control, but even if they are conscientiously watched they will usually lead to a too late interference on the part of the attendants. This disadvantage can be eliminated by mechanical control of the heat by having the measurement of the controlled condition factor automatically and instantaneously produce the impulse required for the correction of possible deviations from the required condition. Gas-pressure regulators are now in use in the large majority of plants with pressure producers; automatic draft regulators have just been introduced in a small number of works and have generally met with fair success. The particular requirements applying to the automatic regulation of furnaces in the glass industry are discussed and it is shown how the different types of regulators with direct

action and those with mechanical, hydraulic, pneumatic, electrodynamic, or electromagnetic relays, try to fulfill these requirements. Latest experiments have given very good results with a combination of gas pressure and mixture regulators, and have shown that, under normal conditions, the difficulties connected with the regulation of the mixture are negligible compared to its great advantages. Greater difficulties arise in the case of automatic temperature regulation within the melting furnace. E.J.V.

Melting of glass. M. VON ROHR. *Z. Instr.*, **48,** 501, 548, 600 (1928).—Guinand devised an optical method for detecting the presence of striae and other defects in glass. The production of defects due to the reduction of the lead oxide caused him to make many experiments on different types of pots, some with double bottoms or with channels in which the metallic lead could be trapped. He continued his experiments on the stirring of the glass, and made tests to ascertain the best speed at which the stirrer should move and the temperature at which the glass should be maintained while the stirring was in progress. His attempts to cast the glass into plates were not very successful. A special egg-shaped furnace was used which was capable of tilting so that the molten glass could be poured from the pot through a channel at the side of the furnace into a mold. Better results were obtained by allowing the glass to cool in the pot, cutting out the best pieces, and heating them in a flattening oven. When the glass became soft, the bed on which it rested was tilted so as to allow it to flow into a circular mold. Guinand paid particular attention to the annealing of the glass, and pointed out the necessity for maintaining, as far as possible, a uniform temperature throughout the mass of the glass and a uniform rate of cooling. He gave detailed instructions with regard to the making of pots and molds, and also with regard to the methods he adopted for the purification of the alkali used in the batch. His annealing oven was about 3 m. by 3 m. by 2 m. It was divided by a horizontal partition into two sections each containing three arched chambers. A flue connected each lower chamber with the one directly above it, the object of the flues being to insure better distribution and more efficient utilization of the heat. The oven was raised to a dull red heat and after the glass had been inserted the chambers were closed and plastered over. The stirrer used in Guinand's later experiments consisted of a clay cylinder about 22 cm. long fixed to one end of an iron rod which was bent at right angles, the other end projecting beyond the furnace wall. With this apparatus, the glass near the wall and also at the bottom of the pot could be reached and, consequently, the stirring was more efficient than with the rotating or reciprocating motion of a straight rod inserted through the top of the pot. Good, homogeneous flint glass was obtained in the summer of 1805. Stirring was begun 12 hrs. after the batch had become molten. The stirrer was introduced when the furnace was at its highest temperature, and stirring was continued for 6 hrs. Good crown glass was also obtained when this method of stirring was adopted. Guinand emphasized the necessity of melting at a temperature higher than that required to melt the sand in the presence of the alkali, and of maintaining a high temperature for several hours in order to allow the bubbles to escape and to permit the molten mass to become homogeneous. (*J.S.G.T.*)

Melting technique of electric lamp glass. O. KNAPP. *Glasindustrie*, **36,** 285 (1928).—The requirements of the glass with regard to quickness of melting at economic temperatures, correctness of expansion coefficient for sealing in, and high degree of durability were stressed. A table of composition showed the modern tendency to be toward glasses relatively rich in dolomite and alkali, for machine working, only special types being now made in flint. Dealing with raw materials, K. gave 0.3% as the maximum value for the Fe_2O_3 content of the sand, which should be dry and fired, and he attached considerable importance to grain size, which should be 0.2 to 0.8 mm. Alkali was introduced as Solvay soda, not as saltcake or hydrated potash, with a little potassium

nitrate; lead as red lead in preference to litharge, which usually had the greater amount of free lead; lime and magnesia as dolomite, barium oxide as barite; and alumina as feldspar, with due check on chemical composition. Allowance should be made for moisture where necessary. Plaining operations were assisted by the use of potassium nitrate or a little saltcake, but too much of the former gave fine "seed." In mixing, the alkalis were weighed out first, then all the remaining materials save the sand, and these were well mixed before adding the latter. Mechanical mixing was advocated, and cullet up to 30 to 40% could be added. For pot melting the usual types of furnace were employed, but the top flame type did not give enough bottom heat. It was advantageous to work the melting stages on reversals and then for working out to employ constant firing. The "Heel of Achilles" as to pot working was the production of the pots, so much depending on care in choice and working of the clay. Grossalmerode clay was generally used with or without some aluminous clay or shale, and the size of the grog was such that it passed 16 meshes/cm.^{2} The ratio grog / raw clay was best obtained by experiment. The mixture was put to "sour" for 6 to 8 weeks, and the pots were dried 3 to 4 months before being arched for a week prior to use. Melting could be controlled by regulating the amount of cullet added, or better, the time of filling, so that the small variations in temperature between pot and pot were compensated. It was usual to "block" the pots once or twice with wet organic matter (potato) and once with "arsenic" before cooling off in 1 to 3 hrs. to the working temperature. In tank work the most important point was the maintaining of a constant level for the machines to draw from, and a clay float worked in conjunction with an indicator lamp was useful as a control. The need for strict control of materials, producers, and working conditions, and also for systematic record keeping was emphasized. It was recommended that the product be compared daily with a standard sample. (*J.S.G.T.*)

Wind system for cooling bottles. ANON. *Ceram. Ind.*, **13** [2], 177 (1929).—A recent development at the Upland Flint Glass Bottle Co., Marion, Ind., is a wind cooling device for cooling the bottles as they travel from the machine to the leer. F.P.H.

Temperature measurements on glass tanks. ANON. *Sprechsaal*, **62** [16], 273–74 (1929).—An optical pyrometer, with compensation means, measuring only radiated heat is described. T.W.G.

Modern glass-forming machinery. ANON. *Engineering*, **128**, 27–29 (1929).—The first of a number of articles on the revolution in the glass industry caused by the development of machinery. Four Miller machines are illustrated. H.H.S.

Hillmann bottle machine. WENDLER. *Sprechsaal*, **62**, [27], 487–89 (1929).—A German design of the Owens bottle machine principle is described and illustrated, suitable for smaller capacities, and with a claim of numerous mechanical improvements over its prototype. T.W.G.

Bureau of Standards announces new process for developing optical disks. ANON. *Amer. Glass Rev.*, **48** [44], 14 (1929). E.P.R.

Development of the incandescent lamp. ANON. *Glasindustrie*, **37**, 1 (1929).—The development of the pipeless, as well as of the stemless (such as automobile) bulb lamp was traced from Jaeger's type in 1903 up to the present time. Pipkin's method of etching the inside, and the universal automatic machine for producing the lamps from bulb blanks, tubes, and wire were described. (*J.S.G.T.*)

Manufacture of wire glass. II. JOSEPH ROSSMAN. *Glass Ind.*, **10** [8], 189–92 (1929).—The air polishing of wire glass, making wire from a single dump or ladle of molten glass by doubling a sheet of glass, guiding the wire into the glass by electromagnets, and some 22 patents dealing with the making of corrugated wire glass are discussed. For Part I see *Ceram. Abs.*, **8** [9], 640 (1929). E.J.V.

British standard specification for illuminating glassware and carriers. BRITISH ENGINEERING STANDARDS ASSN. *Pottery Gaz.*, **54** [626], 1267 (1929).—The specifications cover the dimensions for necks and flanges for illumination glassware and carriers to insure that the glassware and carriers shall be interchangeable. The dimensions have been fixed after due consideration of the external lug-circle diameters of gas mantles, and the dimensions of electric lamps and of bayonet lampholders. The various dimensions for the several types of glassware and carriers are given in tabular form.

E.J.V.

Design of a modern illuminant. HANS K. RITTER. *Glass Ind.*, **10** [8], 202–203 (1929).—An exceedingly high specific surface intensity of the light-source does not fulfill all the requirements which are demanded of an "illuminant." An envelope of glass of the translucent type to surround the light-source is very important, so as to cut down the amount of glare, soften the shadows, and to make the area of glass (opal) large enough for the light to emit from, and therefore to make the surface brightness low. If a glass slat (opal glass) is brought before a light-source, the light obeys the law of diffuse reflection. Under the law of diffuse reflection, when a beam of light strikes the reflecting surfaces, the beam is broken up and the rays of light are reflected in every direction. The direction of the reflected light from the opal glass slats is independent of the angle at which the beam strikes the reflecting surface, the maximum reflection being always perpendicular to the reflecting surface. Therefore it will be realized, that the position of an opal glass slat in relation to space to be illuminated, is in diffuse illumination the main factor in light control. To increase the effectiveness of an "illuminant" advantage should be taken of spread reflection. Under this law, a beam of light striking the reflecting surface is reflected in a certain single direction, as in specular reflection (mirrors) but there is a greater spreading of rays. Lighting fixtures are constructed of glass slats or glass rings. Both types of illuminants have a wide range of usefulness.

E.J.V.

Glass tubing. D. C. BECKETT. *Chemicals*, **32**, 31–32 (1929).—A description of the manufacture of U-tube manometers. Some special forms of these are required to be so accurate that only one tube in 25 passes the tests for internal diameter. H.H.S.

Cut and engraved glass. WALTER BUTTERWORTH, SR. *Glass Ind.*, **10** [8], 184 (1929).—B. outlined the history and development of the various modes of decorating glass throughout the centuries in many countries, beginning with the Egyptian art of cutting and engraving, first gems and precious stones, and then glass. Vases and cups, greatly in vogue in the early Christian era, were copied in glass and glass carving at that time reached its zenith. Hedwig glasses, to be seen in Breslau, Berlin, Amsterdam, and several other places are supposed to date from the 12th or 13th Century, and scholars differ as to their origin, which may be German, Byzantine, or East European. The conventional decorations stand out in high relief, the work of a coarse wheel. The earliest engraving was done by a diamond or flint point. Its origin is not known and the early examples are of great value. After the 16th Century the main cutting and engraving passed to Germany and Bohemia. Following the introduction of coal fuel for glass furnaces English glassmakers produced the new type of glass containing lead oxide, and the distinctively English cutting, to break up light into its many colored constituents, became very popular. The heavy, excessive cutting, with its novel prismatic brilliance led the cutters to neglect the form of the vessel itself. The success of this heavy cutting finally led to the molding or pressing of glass, thereby achieving rapid and cheap production. Many flint glasses made in England were engraved in Holland, and the Low Countries maintained supremacy in engraving. At the present time France, Germany, and Sweden are the centers of experimental engraving.

E.J.V.

Glass improvement in olden and modern times. W. VON EIFF. *Keram. Rundschau*, **37** [21], 361–64 (1929); *Glass Ind.*, **10** [8], 194 (1929).—Every century has its material of esthetic interest. In the 20th Century it is glass. Our interest today is not alone in the esthetic but also in the physical, chemical, and technical properties. The relationship between esthetic and technical in glass can be studied in Venice and Bohemia. Glass cutting and engraving was done in the Orient even in pre-Christian times and in Florence at the end of the middle ages. The method of production underwent a great change with the advent of the new sources of power. Artists interested themselves again in craftsmanship and technique. The reaction came after the World War. With the employment of machines so-called utilitarianism became the slogan. Yet it can be predicted that because of intensive competition the 20th Century will be the century of glass scientifically and artistically. E.J.V.

Manufacture of laminated glass in Japan. JOSEPH H. EHLERS. *Nat. Glass Budget*, **45** [15], 7 (1929); *Amer. Glass Rev.*, **48** [45], 22 (1929); *Commerce Repts.*, **31**, 359 (1929).—Laminated glass is now being manufactured in Japan. The non-shatterable or safety glass is being produced by the Tokushu Garasu Seizosho, of Tokyo-fuka, Japan. Glass used in the manufacture of this product is imported either from the U. S. or Czechoslovakia, and in small quantities from Great Britain. The celluloid used in its manufacture is a Japanese product. At present this glass is produced only in one specification, *i.e.*, 5 mm. thick, 24 in. wide, and 48 in. long. The product of this factory is sold at 4 yen per sq. ft. factory, packing and shipping charge being for the account of the buyer. The productive capacity of the present plant is 200 pieces each month.

Glassmaking in Lancashire. L. M. ANGUS-BUTTERWORTH. *Pottery Gaz.*, **54** [626], 1274–75 (1929).—About one-third of the total number of glass workers in England are to be found in the county of Lancashire. Manchester shares with St. Helens the industrial distinction of being one of the two chief centers of glass manufacture in the county. Hand-made and molded tableware, stained glass, bottles, and jars, and an unrivalled variety of glassware other than industrial glass, which is one of the chief products, are manufactured in Manchester. In St. Helens over 100,000 T. of sheet and plate glass are produced each year, as well as thousands of gross of bottles every week. Two tests for distinguishing between British and German or other Continental glassware are (1) to feel the weight of the glass, the British being heavier due to the use of a high content of lead, and (2) there is a clear, tuneful ring which is had only by the British ware. Foreign competition has made great inroads in the glass industry in Manchester. E.J.V.

Glass as industrial material. ARTHUR D. LITTLE. *Amer. Glass Rev.*, **48** [45], 28 (1929).—Possibilities of glass as an industrial material are discussed. The earliest glasses were opaque, not transparent and devoted almost entirely to decorative uses. Centuries were required for the progression from opaque through translucent to transparent, but examples dating from 4000 yrs. ago show the characteristic transparency we have come to associate with the word glass. It is only within the last 50 yrs. that a serious effort has been made to improve the other qualities of glass. As a result new types of glass with new combinations of properties have been evolved. In this country the research laboratories of Corning Glass Works have been in the forefront of developments. Some of their glasses are distinguished by a low coefficient of expansion, high surface hardness, and marked resistance to water or dilute acids. Heat-resistant glasses are now being introduced into the chemical engineering industries. It was found that special glasses had interesting electrical insulating properties. Through research and large scale experiments, compositions were selected which have since proved their worth as insulation for power and voice transmission lines and for the insulation of radio antennae, transmitters, and receivers. Glass insulators possess a great advantage in being

transparent, for cracks, holes, and other defects that result in poor insulation are readily visible. The new glasses are not readily broken by the heat strains developed by a power arc. Varieties of glass have been made that transmit chiefly in the ultra-violet, others in different parts of the visible spectrum, and still others in the infra-red. Recently in New York City, beautifully decorated glass walls and ceilings were exhibited. A structure has just been erected, on the roof of a skyscraper, built entirely of translucent glass blocks, carried on a steel framework. Etched glass is being used as a substitute for shades and curtains in conservatories. Carved glass is appearing in decorative windows; and to the list of glasses that are transparent to ultra-violet rays has recently been added one containing the rare element beryllium. E.P.R.

Glass as building material. F. HANSEN. *Glas u. Apparat*, **22**, 203ff. (1928).—In a survey of the present uses of glass in building construction H. indicated possible extensions of its application toward the realization of the all-glass house in the coming glass age. This was no mere fancy but the natural climax to be expected from the present tendency to utilize to the fullest possible extent the beneficial effects of pure sunlight. The various forms of sheet glass required for such a purpose were described, namely, window glass, cast glass, plate glass, reinforced-wire glass, pressed glass, etc., with a brief outline of their methods of manufacture, particular details, illustrations being given of the Fourcault window-glass and the Bicheroux plate-glass processes. A concluding reference was made to special products such as quartz glass and its manufacture in the electric furnace, splinterless glass of the Triplex type, and sun-protecting glass, with recommendations as to their specific uses in building construction. (*J.S.G.T.*)

Use for glass. ANON. *Nat. Glass Budget*, **45** [14], 16 (1929).—Plans have been completed for the construction of a three-story glass house on top of a New York building. It will be made of glass "bricks," translucent but not transparent. They will be connected by concrete and steel reinforcing. Interesting effects in lighting will be produced at night when the house is illuminated from within. E.P.R.

Glass as a construction material. ANON. *Brick Clay Rec.*, **75** [4], 228 (1929).—Germany has developed a glass brick and elsewhere in Europe two layers of glass have been used for wall purposes instead of brick. Another late development abroad is the use of molded concrete in construction work. E.J.V.

Blue Ridge Glass Corp. J. N. HAMMER. *Amer. Glass Rev.*, **48** [43], 23–25 (1929).—A new kind of rough, rolled, and wire glass for building purposes in various forms has come from the Blue Ridge Glass Corp. which observed its 2nd anniversary of the start of actual production in May. This corporation was formed by the Corning Glass Works, the St. Gobain Chauny et Cirey Company of France, and the Glaceries Nationales Belges of Brussels, Belgium. The products consist of rough, hammered, ribbed, prism, smooth, and figured glass; rough, ribbed, and figured wire glass and polished wire glass; "Luminex—the Smooth Glass," "Diffusex," "Transex," "Industrex," "Velvex," and polished wire glass. E.P.R.

Larger sheets of glass. ANON. *Nat. Glass Budget*, **45** [14], 20 (1929).—A new clay mold to be employed by the Adamston Flat Glass Company, Clarksburg, W. Va., will make the largest sheets of glass in the U. S. The new "deputy" (debiteuse) will draw a sheet 90 in. wide in comparison with the 60 and 70 in. sheets now being drawn. The huge clay bar sets in a pot of molten glass. Rollers draw glass up through the "deputy" which shapes and forms the product. E.P.R.

Production and sale of glassware. W. MOUFANG. *Glasindustrie*, **10**, 239 (1928).—In an inquiry into the present economical position of the glass industry the opinion was expressed that we now stand at the beginning of a "new glass age" in which extensive use will be made of glass in many spheres to which, hitherto, one scarcely ever gave

a thought. Although at the moment, so far as Germany is concerned, trade is good and prospects are bright, nevertheless it behooves glass manufacturers to take a wider outlook and adopt a far-seeing policy with regard to the range of their productions. At the Exhibition of Glassware held in Berlin during Nov. 1928, producers obtained many hints from the display of ideas and the indicated requirements of buyers to enable them to anticipate the coming development. Through the collaboration of glass-makers and metal-workers, much progress has been made in the art of combining plate glass with metal frames and brackets, and this is bound to have a wide application in architecture during the new age. Another novel feature of the Exhibition was a display of building brick made of transparent glass, but their application in actual practice was still to be approved. Should there be any difficulties in the way, it is the task of the glass manufacturer to remove them and to explore fresh fields for the utilization of these new products. In the various lines of artistic decoration ware a very high standard has been reached, doubtless because in this branch of the industry the initiative has passed out of the hands of the producer. The present-day public has its own ideas about artistic designs, and glassmakers are in duty bound to reproduce these in every detail if sales are to be maintained and expanded. (*J.S.G.T.*)

Belgian Libby-Owens glass plant expands. LEIGH W. HUNT. *Commerce Repts.*, **31**, 359 (1929).—The Compagnie International pour la Fabrication Mécanique du Verre has announced an increase of capital from 66,000,000 F. to 100,000,000 F. for the development of the firm's production in Belgium, where a new plant is now being erected in the Mons region. The initial equipment of the new factory will consist of only 4 machines but it will have an annual capacity of 6,000,000 sq. m. when fully equipped with 6 machines. E.J.V.

Glass company buys gas land. ANON. *Nat. Glass Budget*, **45** [14], 7 (1929).—The Libbey-Owens Glass Company and the Owens-Illinois Glass Company purchased or contracted for 48,000 acres of gas lands in Wayne and Cabell counties. E.P.R.

Bottle industry wage conferences concluded. ANON. *Amer. Glass Rev.*, **48** [44], 14 (1929).—With the exception of a few minor changes, the existing wage scales and working conditions were approved for the coming year in both the hand blown and automatic machine branches of the industry. E.P.R.

European saltcake combine. ANON. *Glass Ind.*, **10** [8], 188 (1929).—French and Belgian saltcake (sodium sulphate) producers are about to enter an international convention, so far confined to the Germans and British, to allocate export markets. The combination would represent about 590,000 metric tons of product, divided as follows: Germany, 290,000 T.; Great Britain, 150,000 T.; Belgium, 80,000 T.; and France, 70,000 T. The Anglo-German agreement expires in 1930 but may be extended 5 yrs. E.J.V.

Roumanian factories using natural gas. J. E. BARABAS. *Glass Ind.*, **10** [8], 203 (1929).—There are window-glass factories in Medias, Diciosanmartin, and Putna. The First Glass Works, in Medias, with natural gas available, has lately introduced the Fourcault process. In 1928 the Transylvanian Glass Works of Diciosanmartin made an arrangement with the Saint-Gobain glass organization and are at present enlarging their factory, introducing there the Fourcault process. There are ten bottle, hollow-ware, and pressed-ware factories, the most important being the Vitromentan Glass Works, Co., Ltd., Media, the Glass Works of Turda in Turda and the Glass Works of Putna. The Vitrometan has recently erected a thoroughly up-to-date factory for the manufacture of white and colored hollow ware, pressed ware and lighting ware, equipped with full automatic American machinery and fuelless leers, the first of modern devices in the hollow-ware glass industry of Roumania. The Glass Works of Turda is producing all kinds of tableware, hollow ware and pressed ware of a fairly good quality.

The Glass Works of Putna, though of small production, is esteemed for its high grade products. A remarkable feature of the Roumanian glass industry is the presence of natural gas which serves as fuel for all plants in Medias, Turda and Diciosanmartin.
E.J.V.

Chilean government to aid window-glass industry. ANON. *Amer. Glass Rev.*, **48** [44], 15–16 (1929).—The government will provide substantial guarantees to the manufacturers of window glass by payment of premiums and granting of special privileges contingent upon a minimum annual production of 3,500,000 kilos of window glass and sufficient invested capital, and the plant must be in operation within three years.
E.P.R.

Purdue professor touring Europe in connection with glass research work. ANON. *Amer. Glass Rev.*, **48** [43], 14 (1929).—Karl Lark-Horovitz, professor of physics and director of the physical laboratory at Purdue University has gained international prominence, because of his fundamental scientific researches in glass during the past few years.
E.P.R.

Manufacture of sheet and window glass. H. SCHNURPFEIL. *Schnurpfeil's Rev. for Glass Works*, **13**, 3243–45 (1929).—There are two standard window glass batches, one containing soda ash as a flux and the other containing Na_2SO_4. The addition of KNO_3, arsenic and manganese to the soda ash batch makes the glass suitable for photographic dry plates. For drawn window glass a softer glass containing barytes is desirable. The soda ash batch may be used as a basis for colored sheet glass and batches are given using the following coloring agents: violet glass using manganese and saltpeter, brown-violet using manganese and iron oxide; carbon yellow using powdered charcoal and Na_2SO_4; yellow using ferruginous manganese; black using manganese and cobalt oxide; green using copper oxide, iron oxide and $K_2Cr_2O_7$; milk-white using red lead, cryolite, feldspar, fluorspar, bone ash and arsenic; aquamarine using copper oxide; blue using cobalt oxide. All these batches have been used successfully.
(*C.A.*)

Significance of Brenker phonolite in the glass industry. HUGO KÜHL. *Schnurpfeil's Rev. for Glass Works*, **13**, 3321–25 (1929).—A study of German minerals for use in the glass industry showed Brenker phonolite to be one of the best natural stones. Its value lies in its high alkali content, which reaches 18%. A typical analysis shows alumina 24, iron oxide 2.3, silica 50.3 and alkali 17.6%. It has been found very suitable for colored glasses, but because of the Fe content its use is limited in the production of colorless glass. Batches from various sources are given using as high as equal parts of sand and phonolite for brown bottles. One part of phonolite to 10 parts of sand may be used for light green medicine bottles. (*C.A.*)

Lead glass and its use. C. A. BECKER. *Metallwirtschaft*, **7**, 230–31 (1928).—Summarizing review on the composition and the technology of Pb glasses. Among the more important applications are table glassware, the optical glasses, imitations of precious and semi-precious stones and protective material for X-ray work (some Pb glasses show the same absorption of X-rays in a 20 mm. layer as solid Pb of 5 mm. thickness). (*C.A.*)

PATENTS

Making plate glass. WILLIAM OWEN. U. S. 1,720,745, July 16, 1929. The combination with a glass-drawing tank, of a pair of sizing rolls above the bath, a tilting take-down frame, movable from a vertical position to a horizontal one, two sets of opposing rolls carried by the frame for receiving the glass sheet which is formed between the sizing rolls and delivered upward thereby, means above the sizing rolls for severing the sheet, a leer in alignment with the take-down frame when it is in its horizontal position, and means for driving the sets of rolls at two different peripheral

speeds, one of which corresponds to the peripheral speed of the sizing rolls for use when the take-down frame is in vertical position, and the other of which speeds is substantially greater than the first speed for use in moving the sheet out of the take-down frame, when such frame is in horizontal position for delivering into the leer.

Glass-working machine. DANIEL KONDAKJIAN. U. S. 1,720,908, July 16, 1929. In a glass-working machine adapted for embedding the end of a metal part in a glass part, in combination; means for holding a glass part; means for holding a metal part; means for moving the glass part and the metal part relative to each other adapted to bring one against the other; means for yieldingly holding the glass part against the metal part under pressure; heating means for glass parts, means for moving the holding means to carry a glass part held thereby into operative relation with the heating means.

Feeding molten glass. KARL E. PEILER. U. S. 1,721,487, July 16, 1929. Apparatus for circulating molten glass, comprising a paddle mounted for engagement with the glass, and means for effecting reciprocation of the paddle at a higher rate of speed in one direction than in the opposite direction.

Glass-working machinery. GEORGE A. MILLAR. U. S. 1,721,570, July 23, 1929. In glass-working machinery, in combination, a pair of work holders axially aligned and extending toward each other, one of them being movable toward and from the other, means for synchronously rotating the work holders, a set of glass-melting fires projecting toward a line between the work holders, means for moving the fires longitudinally between the work holders, means for moving the movable holder away from the other holder, and means operable upon movement of the fires away from the other work holder for measuring and predetermining the distance through which the movable work holder can be moved by its moving means.

Device for handling plate glass panes. MORRIS GLAZER. U. S. 1,721,816, July 23, 1929. In a device of the class described, the combination of a frame comprising a plurality of squares removably attached to a plate-glass pane, with a shoe adapted to snugly and frictionally engage one of the squares formed by the frame, a means for suspending the shoe and a means for swinging the shoe, the pane held thereby and the suspending means onto and from a carrier for the plate glass.

Pneumatic glass circulator. ERNEST G. NELSON, JR. U. S. 1,721,968, July 23, 1929. Apparatus for effecting circulation of molten glass of a pool, comprising a tubular conduit dipping into the glass and having a laterally turned horizontally flared outlet end submerged in the glass adjacent to the surface thereof, and means for applying a fluid pressure impulse to the glass in the outlet end of the conduit to cause horizontal movement of glass of the pool.

Glass. WILLIAM C. TAYLOR. U. S. 1,721,979, July 23, 1929. Method of obtaining an opal glass which consists in melting under oxidizing conditions an acidic batch containing a known metallic element of the even series of the sixth periodic group having an atomic weight between 95 and 185.

Finishing glass articles. JAMES BAILEY. U. S. 1,721,983, July 23, 1929. An apparatus of the class described comprising a frame mounted for movement around a vertical axis, a plurality of containers for the glassware revolubly mounted in the periphery of the frame, a plurality of heating members mounted over the containers the number of heating members being less than the number of containers, each successive heating member being designed to impart an increased amount of heat to the glass, and means for rotating the glassware when it is under the heating members, the rotating means being designed to rotate the glassware at an increasing speed in proportion to the increased amount of heat from the heating members.

Perforating glass. JESSE T. LITTLETON, JR., AND CARLTON R. SMITH. U. S. 1,722,010, July 23, 1929. (1) The method of perforating glass which comprises heat-

ing it until it becomes a conductor of electricity, placing electrodes on either side of the glass at the point where it is desired to form the perforation, placing the electrodes in contact with the glass, passing a current from one electrode to the other, drawing the electrodes slightly apart and maintaining them in this position until the glass is fused, and forcing one of the electrodes through the fused glass. (2) An apparatus for perforating glass, comprising a table to support the glass, a series of electrodes mounted above the glass, a corresponding series of electrodes mounted below the glass, and means for independently moving the electrodes with reference to the glass to permit the passage of an electric current between predetermined pairs of electrodes, whereby the glass may be perforated with a predetermined series of holes without changing its position.

Manufacture of glass articles. SYDNEY HUNT. U. S. 1,722,247, July 23, 1929. In a machine for the manufacture of glass articles, the combination with a casing, of a shaft journaled therein, and a knife fixed to the shaft, the casing and shaft conjointly forming an annular space therebetween for receiving a supply of cooling air, the casing being provided with an outlet for directing the cooling air against the knife.

Sheet-glass drawing apparatus. GEORGE G. ROBERTS. U. S. 1,722,445, July 30, 1929. A crucible for drawing plate glass having a drawing-opening which is substantially oval in horizontal section, the end walls being centrally provided each with a vertical guide-groove for the edge of the sheet, each groove leading to a drawing-corner or edge, the crucible being provided at each end with a depression or pocket communicating with the groove and extending toward the adjacent end of the crucible, these pockets or depressions being positioned to receive molten glass from the crucible and also to receive the ends of the bait.

Apparatus for drawing glass. ARTHUR E. SPINASSE. U. S. 1,722,483, July 30, 1929. In an apparatus for drawing sheet glass wherein the sheet is drawn upwardly from a bath of molten glass, means for forming and maintaining cooler areas of viscous glass as sources from which the edge portions of the sheet are drawn, comprising a pair of internally water-cooled members projecting downwardly into the molten bath, and sheathings of refractory material for the portions of the members within the molten bath, the water-cooled members and sheathings therefor being disposed substantially in a plane containing the drawn sheet, and of such dimension as to localize the cooling effect upon the molten glass at the edges of the sheet for thinning the edges of the sheet and maintaining the width of the sheet.

Handling plate glass. IVAL G. FOWLER. U. S. 1,723,148, August 6, 1929. (1) The combination with means for guiding and conveying a glass plate in an approximately vertical plane, of a traveling carrier and means coördinated with the first mentioned means to swing the carrier into position to receive the plate automatically as it is released from the guide means, and to convey it to the place where it is to be cut, while retaining it in upright position with both faces uncovered so that they may be examined. (2) In a glass-conveying device, the combination of a traveling carrier and a plurality of hangers suspended therefrom, each hanger comprising a comparatively long straight shank portion with a shoe at its lower end against which the lower edge of a glass plate may rest the shank portion being offset at its upper end from the point of suspension, whereby gravity causes the shank portion and the glass plate adjacent the same to assume a slightly inclined position regardless of the weight of the glass. (3) In a glass-conveying device, the combination of a traveling carrier, a plurality of equi-distant swivel members associated therewith, and a plurality of hangers adapted to carry glass plates and selectively attachable to any of the swivel members, each hanger comprising a comparatively long straight shank portion with a shoe at its lower end against which the lower edge of the glass plate may rest, the shank portion being offset at its upper end from the point of suspension, whereby gravity causes the shank

portion and the glass plate adjacent the same to assume a slightly inclined position regardless of the weight of the glass.

Sheet-glass cutting apparatus. JOHN L. DRAKE. U. S. 1,724,261, August 13, 1929. In sheet-glass cutting apparatus, means for supporting a continuously moving sheet, cutter guiding means extending across the sheet and movable therewith a cutter carried by the guiding means and movable vertically toward and away from the sheet independently of the guiding means, and means for counterbalancing the cutter to automatically raise the same away from the glass and hold it in inoperative position.

Glass-pressing and -blowing machine. MAX JAEGER. U. S. 1,724,483, August 13, 1929. (1) In a machine of the class described having a continuously rotating mold table carrying a mold divided into sections, a vertical guideway, a lock head movable in the guideway, a base member spaced vertically from the lock head and also movable in the guideway, a spring to yieldingly transmit motion from the base member to the lock head, and a circular cam to move the base member vertically to effect locking and unlocking of the mold sections. (2) In a machine of the class described, a vertical column, a mold table rotatable about the column, radially movable slides having openings between their ends, mold bottoms projecting upwardly from the slides adjacent their outer ends, blow molds comprising sections pivoted to the table, a ring mold frame above the table, solid ring molds and split ring molds carried by the frame, vertically movable press molds mounted beneath the blow molds, cam means to automatically open the blow molds and close them in coöperative relationship with the ring molds and in embrace of the mold bottoms, cam means to automatically move the slides outwardly when the blow molds are open and thereby remove the bottoms from the blow molds and align the slide openings with the axes of the blow molds, and means to automatically raise the press molds through the openings in the slides to positions between the sections of the blow molds, and in coöperative relationship with the ring molds.

Edge-rounding machine. WILLIAM OWEN. U. S. 1,724,677, August 13, 1929. In combination in an edge-rounding machine, means for supporting a glass sheet and carrying it ahead, a grinding unit in the line of travel of one of the edges of the sheet comprising a driven abrading wheel having its axis of rotation extending approximately at right angles to the line of movement of the edge of the sheet to be ground and mounted for swinging movement around a center within such edge, and means for giving the wheel such swinging movement as the edge of the sheet moves across it.

Feeding molten glass. KARL E. PEILER. U. S. 1,724,678, August 13, 1929. In glass feeding apparatus, a container for molten glass having a continuously open delivery outlet below the glass level and uncontrolled during feeding, and means operating in the glass in the container for periodically causing lateral movement of part of the glass in the container in such manner that such lateral movement of glass in the container impels glass through the outlet.

Plate-glass transfer apparatus. JOHN H. FOX. U. S. 1,724,703, August 13, 1929. A process for producing and surfacing sheet glass which consists in forming the glass in a continuous, forwardly moving ribbon, annealing the ribbon as it moves forward, gradually turning the ribbon from a horizontal to a vertical plane after it is annealed and surfacing the opposite sides of the glass at the same time as it moves forward in a vertical plane.

Surfacing sheet glass. JOHN H. FOX. U. S. 1,724,704, August 13, 1929. A process for surfacing a continuous ribbon of glass which consists in carrying the sheet beneath a series of surfacing machines to smooth the upper side, then twisting the ribbon gradually through 180° to bring its other surface up, and carrying the ribbon beneath a second series of surfacing machines to smooth such other surface.

Preparing vitrified material. PETRUS M. COCHIUS. U. S. 1,724,747, August 13, 1929. Process of preparing a glass-like opaque material, which comprises rendering homogeneous a glass material with an excess of sand, partially melting in the usual way and working the mass into shaped products before the sand is wholly dissolved in the fusion.

Manufacture of fused quartz beams, etc. ROBERT WILLIAM CLARK AND LESLIE SAMPLE. U. S. 1,724,793, August 13, 1929. A process for producing beams from a mass of fused silica, comprising converting the mass into an ingot having the required cross-section on an enlarged scale and a length on a proportionately reduced scale, passing the ingot in eccentric alignment progressively through a surrounding preheating zone to bring it to a temperature just below the softening stage, passing the ingot through a surrounding highly localized maximum temperature zone to give it the required degree of plasticity, and drawing the beam out eccentrically through a relatively long post heating zone at a lower temperature.

Manufacture of articles of silica glass by addition of material. PIERRE HENRI CLÉMENT LA BURTHE. U. S. 1,724,844, August 13, 1929. A process for the manufacture of fused silica articles of diverse shapes by adjunction of material to a previously formed silica member, consisting in packing pulverulent silica around the member, and in heating the parts of the member where the adjunction of material is to be caused, together with the adjacent parts of pulverulent silica which has been packed about the member to a temperature adapted to cause the complete fusion of the parts of the silica member and of the parts of pulverulent silica and to insure an intimate welding of both parts.

Drawing sheet glass. P. HADDAN. Brit. 311,171, July 3, 1929. Apparatus for drawing sheet glass comprises an enclosed drawing chamber arranged vertically above a crucible chamber and separated from it by a water-cooled shield, and means are provided for controlling the temperature of the sheet at its point of formation, and for transferring the sheet to the leer without removing it from the drawing chamber.

Cutting glass. NAAMLOOZE VENNOOTSCHAP MIJ. TOT BEHEER EN EXPLOIT. VAN OCTROOIEN. Brit. 311,408, July 3, 1929. Relates to apparatus for cutting plate or sheet glass while it is still hot and plastic and while it is lying on the tables on which it is received from the rolling machine. The glass strip is received on a number of tables set end to end and separated by small gaps, or on a single table provided with transverse recesses or gaps, and the strip is cut into sections by a blade or cutting device which is driven down through the glass into the gaps. According to the invention a cutting device is used which exerts pressure on the glass where it is disposed across a gap and then severs the glass along the edges of the gap to remove the waste strip thus defined.

Cutting glass. NAAMLOOZE VENNOOTSCHAP MIJ. TOT BEHEER EN EXPLOIT. VAN OCTROOIEN. Brit. 311,770, July 10, 1929. Relates to apparatus for cutting sheet glass while it is still plastic and while lying on the tables which receives it from the rolling apparatus to transport it to a leer.

Glass annealing. NAAMLOOZE VENNOOTSCHAP MIJ. TOT BEHEER EN EXPLOIT. VAN OCTROOIEN. Brit. 311,771, July 10, 1929. Relates to the method of making plate or sheet glass intermittently in which the glass plates, as they leave the rolling mechanism are received on a roller track by which they are carried to and through a leer. As soon as the glass has set sufficiently, its speed is reduced from the high speed at which it is rolled to the low speed at which it is carried through the leer. The invention consists in providing at the first section of the leer two sets of conveying rollers driven at the high and low speeds at which the glass plate travels, the rollers of one set alternating with those of the other. Means are provided for independently raising each

set of rollers into the feeding-position and for lowering it therefrom. In operation; the high-speed rollers are raised to receive a glass plate as it enters the leer. As soon as the glass has set, the high-speed rollers are lowered, and the low-speed rollers are raised into position to support the plate and feed it forward on to the next set of rollers.

Glass-annealing leers; conveyers. NAAMLOOZE VENNOOTSCHAP MIJ. TOT BEHEER EN EXPLOIT. VAN OCTROOIEN. Brit. 311,772, July 10, 1929. In a roller conveyer for glass-annealing leers, the rollers are formed of inner and outer hollow cylinders which are in contact at a few spaced points only and are separated by heat-insulating material. The contacts between the cylinders are formed by annular ribs on the two parts, while, to permit longitudinal expansion, the outer shell is secured to the shaft at one end only. Cooling medium is passed through the inner shaft.

Glass rolling. NAAMLOOZE VENNOOTSCHAP MIJ. TOT BEHEER EN EXPLOIT. VAN OCTROOIEN. Brit. 311,773, July 10, 1929. Relates to the method of making plate glass in which the whole refined contents of a melting pot are dumped onto the receiving table of a double-roll machine and are formed into a strip. According to the invention, the contents of the second and further pots are poured onto the receiving table while it still contains a substantial quantity of the glass from the preceding pot. The process is thus made continuous instead of being intermittent, and loss of glass, due to the defective head and tail ends of the rolled strip, is reduced.

Frosting glass. CORNING GLASS WORKS. Brit. 312,054, July 17, 1929. In the preparation of an etching slurry or solution for frosting lamp bulbs and other glass articles, certain of the ingredients are fused prior to being ground and incorporated with the other ingredients so that a thinner slurry for a given strength is produced allowing of more economical use. In preparing an etching solution containing sodium fluoride and soda ash, these materials are separately fused and ground and then mixed with suitable proportions of ammonium carbonate, hydrofluoric acid, ammonium bifluoride, and water. The resulting mixtures are then mixed together to form the etching solution. Instead of fusing the whole of the sodium fluoride and soda ash, a part only of one or both may be fused, the remainder being ground in the unfused state. Potassium fluoride may be used instead of sodium fluoride.

Glass rolling machine. NAAMLOOZE VENNOOTSCHAP MIJ. TOT BEHEER EN EXPLOIT. VAN OCTROOIEN. Brit. 312, 072, July 17, 1929. A double-roll machine for making plate or sheet glass has a rotatable vertical roller arranged behind the forming-rolls on each side of the path of the newly-formed glass plate. The vertical rollers engage a plate as it emerges from between the rolls and smooth and straighten its edges.

Glass blowing. A. SCHILLER. Brit. 312,159, July 17, 1929. A machine of the Schiller type for blowing glassware has its molds, and the ring mold tongs, formed with two or more molding-cavities so that two or more articles are produced simultaneously. In order that the cavities in the ring mold tongs may be properly centered with those in the parison and finishing molds, the bodies of the molds and tongs are provided with flanges or other parts which are circular in outline.

Glass manufacture. CORNING GLASS WORKS. Brit. 312,310, July 17, 1929. A heat-absorbing glass is made by melting, under reducing conditions, a batch containing silicon, boron, zinc, or cadmium, or a mixture of both, and iron, an alkaline earth being added if desired. The glass is rendered heat-absorbing by ferrous oxide which, owing to the presence of the zinc or cadmium, imparts to the glass a blue-green color instead of the amber or brown color which it usually gives to a borosilicate glass. Lime or other alkaline earth may be added with advantage provided that it does not exceed in amount the zinc or cadmium. The batch may also contain tin as its presence, where cadmium and not zinc is present, causes a more complete reduction of the iron than is otherwise possible. Carbon or a carbonaceous material, preferably sugar, is added to

the batch as a reducing agent, but any other reducing agent which will not impart undesirable color to the glass may be used. The proportions of a number of glasses are given in the description, and Brit. 312,311 is referred to.

Glass manufacture. CORNING GLASS WORKS. Brit. 312,311, July 17, 1929. A method of modifying the color of glasses, which contain zinc or cadmium together with a substantial quantity of ferrous iron and a reducing agent, consists in adding to the batch a small quantity of tin or of a substance containing tin. The method is used in producing a heat-absorbing glass, the ferrous iron, in the presence of tin, imparting a pure blue color to the glass instead of the green color which is usually obtained. The glass also possesses great power of absorbing both the infra-red and visible red. It also absorbs the ultra-violet and has a relatively high transmission for the remainder of the visible spectrum. On this account, the glass may be made suitable for use in welder's glasses by increasing the quantity of ferrous iron and adding nickel oxide or other substance which will impart to the glass a complementary or red color. In making the glass, ferric oxide and stannic oxide or putty powder are added to the batch with sufficient carbon to cause the reduction of both of these ingredients. The zinc or cadmium can be replaced by calcium, magnesium, strontium, or barium. The percentage composition of a number of glasses, and batches for producing them, are given in the description. Brit. 312,310 is referred to.

Glass manufacture. CORNING GLASS WORKS. Brit. 312,346, July 17, 1929. A batch for producing an opal glass, suitable for making electric lamp bulbs, contains silica, alkali, an alkaline earth, alumina, boric oxide, zinc oxide, and a fluoride. The alkali content is about 10%, the alumina content is about 8%, the alkaline earth content is about 4%, the boric oxide content exceeds 6%, and the zinc oxide content is not greater than 8%.

Glass manufacture. CHANCE BROS. & CO., LTD., C. E. GOULD, W. M. HAMPTON, AND H. S. MARTIN. Brit. 312,728, July 24, 1929. Relates to glass of the kind that is transparent to ultra-violet rays, and to the tendency of such glass to lose part of its power of transmitting the rays. The invention consists in making a glass which is less subject to the defect in question by using ingredients which substantially avoid the occurrence in the finished glass of dissolved gaseous oxides. For this purpose, a batch may consist of silica, borax, and a powdered metal, such as zinc, aluminium, or tin, which combines readily with oxygen and acts as a reducing agent.

Glass manufacture. W. J. MILLER. Brit. 312,887, July 24, 1929. A device for feeding charges of molten glass comprises a tubular conduit extending vertically from the outlet of a forehearth to a height just above the normal level of the glass, an annular wall surrounding the conduit, and a cylindrical plunger or impeller which telescopes into the space between the conduit and the wall and is reciprocated to cause a pulsating flow of glass from the forehearth through the conduit and thence through the outlet.

Glass-annealing leers. UNITED GLASS BOTTLE MANUFACTURERS, LTD., T. C. MOORSHEAD, AND F. A. HURLBUT. Brit. 312,890, July 24, 1929. A glass-annealing leer having an endless conveyer and heated adjacent the ware-receiving end.

Glass manufacture. AMERICAN THERMOS BOTTLE CO. Brit. 313,146, July 31, 1929. Relates to the method of manufacturing vacuum flasks.

Cutting glass. R. SHAW. Brit. 313,647, August 8, 1929. Relates to a device for cutting ellipses from flat plates or sheets particularly of glass, and in which the cutting-edge of the cutter is held in a direction which is always tangential to the ellipse at the point being cut. According to the invention, a known type of apparatus is provided with an additional four-link mechanism for automatically keeping the cutter in the right direction.

Drawing sheet glass. P. HADDAN. Brit. 313,821, August 8, 1929. Relates to apparatus for drawing sheet glass and to means for applying an outward pull to the edges of the sheet in order to maintain its width. According to the invention, the apparatus comprises an elongated drawing-pot having pockets or recesses formed in its upper sides at both ends and extending outwardly beyond the drawing-points or corners of the pot, and a bait bar of such a length that its end rests in the recesses when it is lowered onto the pot at the commencement of a draw. The pot may be a separate receptacle or it may be connected with a tank furnace so that molten glass flows constantly into the pot and is kept with its surface approximately level with the upper edge of the pot. The end walls are rounded and are provided with vertical guiding-grooves. Pockets are formed in the end walls in communication with the grooves and these pockets, which are filled with glass when the pot is in use, receive the ends of a bait bar when it is lowered. The bait is preferably constructed with a slot in its underside and means are provided whereby air may be withdrawn from its interior in order to draw the glass into the slot. When a draw is being made, the edge of the glass sheet will be formed in the grooves and the sheet will draw off the upper corners. Because the bait is longer than the distance between the two corners the edges of the sheet are pulled outward and the tendency of the sheet to become narrower as the draw proceeds is counteracted.

Sealing glass vessels. PATENT-TREUHAND-GES. FÜR ELEKTRISCHE GLÜHLAMPEN. Brit. 313,850, August 8, 1929. A machine for evacuating and sealing ampoules, and similar glass bulbs.

Distributor for molten glass from the furnace. ALFRED BOUCHER. Fr. 33,709, March 19, 1927. Addition to Fr. 640,854. (*C.A.*)

Glass. IMPROVED GLASS PROCESS, INC. Fr. 651,985, March 30, 1928. $BaSO_4$ is added to the constituents of glass to give a brilliant and easily worked glass. The addition is sufficiently small to avoid the formation of foam or of a molten layer of sulphate on the glass. Decolorization may be effected by a substance containing Se, Mn, etc. (*C.A.*)

Glass. IMPROVED GLASS PROCESS, INC. Fr. 652,036, March 31, 1928. The $BaSO_4$ of Fr. 651,985 is replaced by BaS, which may be obtained by reduction of $BaSO_4$, residues of $BaSO_4$ diminishing the formation of foam during the fusion. (*C.A.*)

Melting furnace for the production of gas-free glass. L. SANCHEZ-VELLO. Ger. 459,221, May 12, 1923. The furnace comprised a melting pot surrounded by an electrical heating element and containers of low thermal conductivity, hermetically sealed and provided with apparatus for evacuating the air. To accommodate the melting crucible, a nest of three containers, which may be covered, is arranged inside the evacuation container. Of these the inner one consists of a heating element covered by refractory material, the next, a metal container having polished walls, and the third consists of an insulating material. (*J.S.G.T.*)

Heavy Clay Products

Influence of calcium sulphate in brick. ANON. *Rev. mat. constr. trav. pub.*, No. 229, pp. 227–28B (1928). A.J.M.

Treatment of clays containing calcium carbonate. ANON. *Rev. mat. constr. trav. pub.*, No. 224, pp. 114–15B (1928). A.J.M.

Properties of clay and its preparation for use in brickmaking. HANS HIRSCH. *Tonind.-Ztg.*, **53** [20], 407–409 (1929). F.P.H.

Behavior of ceramic products when subjected to wide temperature variations and chemical agents. V. SKOLA. *Tonind.-Ztg.*, **52** [101], 2018–21 (1928). F.P.H.

Processing of dry-pressed ware. ANON. *Brick Clay Rec.*, **75** [4], 217–19 (1929).—When vitrified brick are manufactured for use in the construction of marine work, tunnels, canal foundations, and for paving, their color and appearance is less important than in the case of vitrified brick used in the construction of buildings. There are other characteristics, however, that are of more important consideration, such as compressive strength, absorption of water, resistance to freezing, toughness, abrasion, and structural condition. The dry-press process for vitreous brick manufacture is especially desirable for this type of brick. Results of tests have shown that the abrasion of the dry-pressed brick is 30% less than of the wet-pressed brick, and the sandblast test showed even a difference of 50%. The tests of other characteristics of the brick are more favorable to the dry-press process. They showed that by means of the new Spengler dry-pressing process, a paving brick can be produced which equals the highest grade natural stone. The preparation of the raw materials for manufacturing the brick by this process involves either one of two methods: one for hard and dry, such as shale or hard pan; and one for soft materials, such as clay and alluvial earth. In the first method the material is crushed and then ground in two high-output dry pans, the first having sieve openings of $^{15}/_{64}$ in. diameter, and the second having perforations $^{7}/_{64}$ in. in diameter, where it is ground to fine pressing powder. In the handling of soft- and stiff-mud process clays the raw material is dried before being delivered to a high-speed pan where it is ground to $^{1}/_{4}$ in. diameter. Full details of this modern development in the process are given. E.J.V.

Buildings for natural drying with mechanical handling of drying boards. E. G. GUERRÉR. *Rev. mat. constr. trav. pub.*, No. 226, pp. 145–49B (1928).—G. gives drawings of drying racks, drying boards, a building of 300,000 brick capacity and one of 100,000 brick capacity. The materials required for the structures are listed. A.J.M.

Drying brick. L. DEVILLER. *Rev. mat. constr. trav. pub.*, No. 225, pp. 126–30B (1928).—D. presents a complete review of the subject. A.J.M.

Humidifier for small brick plants. P. V. PINKL. *Rev. mat. constr. trav. pub.*, No. 224, pp. 115–16B (1928). A.J.M.

Artificial and natural drying. P. THOR. *Rev. mat. constr. trav. pub.*, No. 224, pp. 109–14B (1928). A.J.M.

Open-air driers. ANON. *Rev. mat. constr. trav. pub.*, No. 223, pp. 86–87B (1928).—Drying data are given for a Danish brick plant. A.J.M.

Efflorescence. ANON. *Rev. mat. constr. trav. pub.*, No. 226, pp. 164–65B (1928).—A table is given on the causes and means of prevention of efflorescence. A.J.M.

Freezing tests on sand-lime brick. ANON. Bur. Stand., *Tech. News Bull.*, No. 147, pp. 67–68 (1929).—Some preliminary tests have been made to determine the best procedure for conducting a series of freezing tests on sand-lime brick. Twenty-four bricks of a single manufacture were used. They were divided into 4 groups, each group representing as nearly as possible an equal range of absorptions, as determined by a 72-hour cold-immersion test. All brick were given 10 cycles of freezing and thawing, the procedure being varied for each group. After 10 cycles the brick were dried at 110°C and reweighed. The loss in total weight ranged from 0.3 to 2.8% of the original dry weight. The average increase in absorption for all brick was 2.8%. R.A.H.

Causes of discoloration in the firing of argilaceous products; means of prevention. E. BUCH. *Rev. mat. constr. trav. pub.*, No. 232, pp. 14–16B (1929). A.J.M.

Absorption properties of clay brick. L. A. PALMER. Bur. Stand., *Jour. Research*, [RP] 88, **3** [1], 105–27 (1929).—The absorption properties of 10 different types of clay brick have been studied. Certain simple empirical equations were found to fit these

absorption data within the limits of experimental error. Three constants have been evaluated. Two of these, *B* and *C*, are derived by a method of computation of the data obtained in the study of rate of absorption by partially immersing brick in water. The third, the absorption constant, *K*, is obtained by immersing the brick in water at normal room temperature for a more or less definite period and following this immersion in boiling water for 7 hrs. The Schurecht ratio, slightly modified, is used in evaluating *K* for any type of brick. It is indicated that the constants, *B*, *C*, and *K*, are more characteristic of a given clay or shale from which a type of brick is made than they are of any other single thing. The absorption constant, *K*, is independent of the heat treatment that the clay body has received over a certain limited range in the firing temperature. It may be possible to relate the absorption constant, *K*, characteristic of a manufacturer's brick, to the weather resistance of that material, and this constant and the others, *B* and *C*, may furthermore be of use in differentiating between underfired and overfired brick on one hand and well-fired brick on the other. It is believed these constants will be of value in the study of the process of water penetration through brick masonry. R.A.H.

Thermal conductivity of various building materials. ANON. *Tonind.-Ztg.*, **52** [94], 1878–80 (1928).—The following values are given for the thermal conductivities of some common building materials:

Material	Sp. gr. (kg./m.³)	Temp., °C	Thermal conductivity number
Sandstone	2250	10	1.33
		20	1.44
		40	1.58
Concrete block in mortar		31	1.01
Brickwork from old house	1850	0	0.328
		20	0.35
		47	0.38
Brickwork new (25% moisture)	1961	10	1.2
The same 4½ months old, (3.4% moisture)	1763	10	0.84
The same 6 months old, (1.9% moisture)	1748	10	0.74
The same 9 months old, (1% moisture)	1737	10	0.60
Fired kieselguhr brick	200	50	0.071
		100	0.078
		200	0.092
		300	0.106
		400	0.120
Fired kieselguhr brick	748	50	0.132
		100	0.158
		150	0.186

F.P.H.

Compressive and transverse strength of brick. J. W. MCBURNEY. *Clay-Worker*, **92** [1], 25 (1929); partially reprinted from *Jour. Amer. Ceram. Soc.*, **12** [4], 217–29 (1929).—See also *Ceram. Abs.*, **8** [5], 334 (1929). E.J.V.

Water absorption and penetrability of brick. J. W. MCBURNEY. *Clay-Worker*, **92** [1], 38 (1929).—Values obtained from the determination of water absorption and penetrability by a number of methods on a variety of makes of brick representing a considerable range in properties and methods of manufacture are recorded. The value of water absorption as a measure of resistance to frost action is discussed. The mechanism of water transmission through masonry is discussed from the standpoint of absorption properties of the units. On the basis of the data recorded and field observation, it is considered that the water absorption or apparent porosity of brick is not a measure of resistance to climatic action insofar as differences in raw materials and methods of manufacture are involved. For the same clay or shale and for the same method of forming, the difference between satisfactory and unsatisfactory weathering

performance may be distinguished by difference in water absorption. It is believed that while Schurecht's ratio (water absorption, 48 hr. cold immersion to water absorption, 5 hr. boiling) is a much better measure of disintegration through freezing and thawing, than is water absorption by any one method, it is not sufficiently reliable to furnish a basis for classification. E.J.V.

Coöperative research on crushing strength of clay brick at room temperature. GROOTHOFF. *Tonind.-Ztg.*, **53** [21], 430–34 (1929).—An investigation of methods of determining crushing strength of brick was made and results on various brands and with various types of test pieces are presented. F.P.H.

Study of the rattler test as practiced in the U. S. I. F. WATTEBLED AND F. CARINI. *Rev. mat. constr. trav. pub.*, No. 226, pp. 164–67B; **II.** *Ibid.*, No. 227, pp. 187–89B (1928). A.J.M.

Deterioration of brick constructions. ANON. *Rev. mat. constr. trav. pub.*, No. 223, p. 90B (1928). A.J.M.

Permeability to water of building materials. V. BODIN. *Rev. mat. constr. trav. pub.*, No. 226, pp. 150–54B (1928).—B. discusses porosity, resistance to freezing, and permeability, emphasizing that there need not be any relation between them. Data are given showing that the determination of permeability by means of air does not give results in agreement with the method using water. In one case results by the latter method were 23 times as great as those obtained by the former. Procedures are given for permeability determinations. A.J.M.

High-speed chain in soft-mud brick plants. THOMAS K. BROWNE. *Brick Clay Rec.*, **75** [4], 236 (1929).—The soft-mud brick yard of a few years ago has been placed on a plane with modern manufacturing plants through the improvements of the last few years. The connecting link between the source of power and the machinery is one item that has not been developed to its greatest point of practical efficiency. Belts require long centers, large diameter pulleys, and are subject to the action of several elements that decrease their coefficient of friction or driving power. They will, however, slip when a machine plugs or jams and in so doing act as a safety device. High-speed silent chain can now be installed to include and improve on this desirable feature as the result of the development of an efficient, reliable shearing pin sprocket. Other advantages of high-speed chain are that it is at all times a positive drive with no slip; short centers save valuable room and eliminate overhead construction; pinions and sprockets are of small diameter. They also have a lower friction load and have a long service life. E.J.V.

Wintering of plastic pyritic clays. ANON. *Tonind.-Ztg.*, **53** [16], 315 (1929).—Pyrite decomposes between 600 and 700°C and forms pits in the brick. With lime-free pyritic clays, weathering is necessary. A rapid fire tends to bloat brick containing pyrites. F.P.H.

Rational operation of kilns in the brick plant. BRUTSCHER. *Rev. mat. constr. trav. pub.*, No. 222, pp. 62–63B (1928). A.J.M.

Replacement of machines in brick and tile plants in France. M. AUGEREAU. *Rev. mat. constr. trav. pub.*, No. 230, pp. 254–56B (1928). A.J.M.

Utilization of waste in brick plants. ANON. *Rev. mat. constr. trav. pub.*, No. 231, pp. 275–76B (1928).—Defective brick may be crushed and used in concrete construction as a coarse aggregate. Brick may also be powdered and the dust used as an insulating material when mixed with other materials to form plasters or coatings, in magnesian cements, and as an insulator for pipes, etc., by mixing with plastic clay and water-glass. Brick dust may be added to brick to make them slightly more porous or to decrease the plasticity of the clays. Bricks containing brick dust may be fired at a higher temperature. A.J.M.

Importation of brick into the U.S. ANON. *Rev. mat. constr. trav. pub.*, No. 231, p. 286B (1928).—Imports in 1926 were 114,346 m. and in 1927, 96,198 m. The value in 1926 was $933,907 and in 1927, $568,938. A.J.M.

Fired clay in modern building. I. H. GILARDONI. *Rev. mat. constr. trav. pub.*, No. 227, pp. 173–77B; **II.** *Ibid.*, No. 228, pp. 201–204B (1928). A.J.M.

Extending the field of clay products. ANON. *Clay-Worker*, **92** [1], 21–23 (1929).—The market field for clay products is big, and is broadening every year, but there is also an insistent increase in the production so that there arises the problem of how to market the products profitably. Among possibilities for brick and tile are bridges, barns, culverts, fountains, brick steps, pillars or columns, as linings for ash pits or bins in power plants, and around garbage and incinerator plants. E.J.V.

Renaissance of common brick. HUGH FILIPPI. *Brick Clay Rec.*, **75** [4], 220–23 (1929).—F. presents a dramatic story of common brick's decline and its recent remarkable rebirth. E.J.V.

Popularizing the use of paving brick. FERNAND WATTEBLED AND FEDERICO CARINI. *Rev. mat. constr. trav. pub.*, No. 225, pp. 131–35B (1928). A.J.M.

Brick churches. H. B. JONES. *Brick Clay Rec.*, **75** [4], 229–32 (1929).—J. makes a strong plea to brick manufacturers to turn their merchandising efforts to churches. E.J.V.

Wewoka Brick and Tile Co. plant. ANON. *Clay-Worker*, **92** [1], 39–40 (1929).—A detailed description of this 40,000 brick plant and its equipment is given. The shale deposit is one of the finest in Okla. E.J.V.

Brick industry and trade in the Netherlands. GEORGE TAIT. *Commerce Repts.*, No. 32, pp. 422–23 (1929).—Brickmaking is carried on in practically all parts of the Netherlands. Nine of the Kingdom's 11 provinces are producers of brick, with approximately 550 plants in active operation, almost half of them on the River Waal. These establishments range from small yards with 5 or 6 employees each, to large, modern, well-equipped plants employing as many as 500 workers. Production has been increasing, with an estimated output of 1,750,000,000 brick in 1928. About 85% of the present Netherland production consists of face brick, the remainder being the common, unglazed building, and paving variety. Production of types such as fire brick is unimportant. While the total exportation of brick has grown from 20,000,000 in 1924 to 85,000,000 in 1928, exports to the U. S. have declined from 23,000,000 in 1926 to 9,000,000 in 1928. E.J.V.

BOOKS

Homes of Permanency. STRUCTURAL CLAY TILE ASSN.—This booklet not only describes the uses to which structural clay tile can be put, but also shows a complete line of 4-, 5-, and 6-room homes of every known type in which this product has been used. Reviewed in *Brick Clay Rec.*, **75** [3], 166 (1929). E.J.V.

Structural Clay Tile Buildings for the Up-to-Date Farmer. STRUCTURAL CLAY TILE ASSN.—A booklet which describes briefly the use of structural tile in all forms of farm building construction and the economies possible to the farmer wherever structural clay tile is used, has just been issued. Reviewed in *Brick Clay Rec.*, **75** [3], 155 (1929). E.J.V.

PATENTS

Locking tile. TONY ROTA. U. S. 1,722,682, July 301, 929. A wall structure combining a plurality of horizontally disposed interlocking hollow building blocks, each having horizontal top and bottom walls, vertical connecting side walls, and partitions, and a horizontal wall forming a partition about midway of the blocks, the blocks having continuous openings extending therethrough between the partitions and walls, the bottom wall of each block being omitted at two points between respective pairs of partitions

thereby providing remaining sections of the bottom wall forming bearing surfaces at the sides and in the center, the side walls of the open spaces provided by the omission of the sections of the bottom wall being tapered and converging toward the bottom; the top wall of the blocks having vertical walls extending upward therefrom in a plurality of sets with the walls of each set connected at the top by horizontal walls and the outer surface of the walls of the sets being tapered and converging downward thereby providing tongues with openings extending therethrough on top of the blocks adaptable to engage the openings in the lower sides of a succeeding block formed by the omission of the sections of the bottom plate.

Porous ceramic ware. R. LAHAUSSOIS. Brit. 311,761, July 10, 1929. Porous ceramic articles are made by incorporating in the mix crushed carbon, etc., which may contain alkalis, and subjecting the molded article to two firings, first at a temperature exceeding 1200°C in a reducing atmosphere, then at lower temperature, *e.g.*, between dark and glowing red, in an oxidizing atmosphere which burns out the combustible material and allows the alkali contained therein to form an enamel, coating each cell and insuring cohesion.

Brick machines. CLAYTON, GOODFELLOW, & CO., LTD., AND T. WHITTAKER. Brit. 312,491, July 24, 1929. In machines wherein the plastic material is successively molded and repressed in a pair of mold boxes coöperating with upper and lower pistons, the lower repressing piston is retained in its uppermost position until the upper repressing piston makes contact with the upper surface of the green brick.

Refractories

German standards for refractory materials. ANON. *Tonind.-Ztg.*, **52** [102], 2040–42 (1928).—The following standard methods for testing refractory products are described: (1) load test, (2) shrinkage, (3) compressive strength at room temperature, (4) specific gravity, and (5) porosity. F.P.H.

German and American standardization of refractory building materials. F. HARTMAN. *Stahl u. Eisen*, **49**, [20], 727–32 (1929). T.W.G.

Refractories. ANON. *Ceram. Age*, **12** [5], 182 (1929); *Refrac. Jour.*, **4** [46], 331 (1929).—Considerable data relating to specifications for refractories are given together with outlines of various tests applied. E.P.R.

A manufacturer's viewpoint regarding specifications. GEORGE A. BALZ. *Refrac. Jour.*, **4** [46], 304–305 (1929).—In the abstract, specifications are a most essential factor in progressive industrial development. Specifications, by serving as a target at which manufacturers are either inclined or compelled to aim, have contributed to the development that has occurred in most branches of American industries during the past decade. One of the most undesirable aspects, from a manufacturers' viewpoint of the present increasing tendency toward specifications in our industry, is the ever-present danger that specifications developed for a particular class of service will, in ignorance, and perhaps with a desire to reduce the purchaser's responsibility to a minimum, lead to more or less wide misapplication of refractories. The raw materials used in the manufacture of refractories vary considerably in their properties which is an important factor in producing a uniform product. For this reason each manufacturer must study his materials so as to produce the best possible product for a given class of service. The same mixture of clays, method of forming, and degree of firing are seldom applicable to more than one plant. With particular reference to the water-spalling test, as provided in most specifications it is B.'s opinion that this test should be discarded as it appears in no manner simulative of actual service conditions. Let us have specifications that are carefully prepared, after thorough deliberation by both parties,

and let such specifications be amenable to revision from time to time as practical experience may indicate. E.P.R.

Status of tests for refractories. S. M. PHELPS AND J. S. MCDOWELL. Amer. Soc. Mech. Engrs., paper for meeting May 13–16 (1929). *Trans. Amer. Soc. Steel Treating*, **16** [2], 336 (1929).—Tests for refractories are divided into three general types; (1) durability, (2) suitability, and (3) control; pyrometric cone equivalent; standard load test; reheat test; water-immersion spalling test; use of tests in selection of refractories. E.P.R.

Refractories research. BOERICKE. *Mining and Met.*, p. 168 (1929); *Refrac. Jour.*, **4** [46], 332 (1929).—Reference is made to recent methods of research which are being applied to refractories, together with the possible industrial applications of the results of such researches. E.P.R.

Corrosion of refractory material. W. NEIMANN. *Tonind.-Ztg.*, **53** [24], 484 (1929).—The usual method of placing slag in a hollow test-piece was used. A slag with a melting point of 1350°C is usually used. In testing glass refractories it is best to use glass of the same composition as that to be made as the flux, and a temperature equivalent to that to which the refractories are to be subjected. F.P.H.

General properties of refractory products. ROBERT LEDUC. *Rev. mat. constr. trav. pub.*, No. 226, pp. 155–57B (1928). A.J.M.

Tests and uses of refractory products. E. H. SCHULZ. *Rev. mat. constr. trav. pub.*, No. 234, pp. 60–62B (1929).—Refractories are considered from the viewpoint of the metallurgist. A.J.M.

Variation of strength of refractory material with temperature. HANS HIRSCH. *Tonind.-Ztg.*, **53** [1], 2–8 (1929).—A new apparatus for determining the compressive strength of refractory materials at elevated temperatures is described. The strength of refractories varies with temperature. The strength of clay refractories increases with temperature and reaches a maximum in the region of 1000 to 1200°C. Above this maximum the strength decreases with temperature until the softening temperature is reached. The maximum appears simultaneously with the appearance of the glass phase. The type of fluxes present influences the course of the compressive strength-temperature curve as well as the position and magnitude of the maximum. This curve is also affected by the method of preparation and firing treatment to which the material has been subjected. The following results are presented showing the effect of method of preparation on the compressive strength and softening behavior of clay refractories:

Method of preparation	Hand made	Pressed	Repressed	Machine made
Firing temp.	Cone 14	Cone 14	Cone 14	Cone 14
SiO_2	54.7	55.10	59.6	56.0
Al_2O_3	43.9	43.4	37.2	38.7
Fe_2O_3	1.1	1.2	1.5	1.90
TiO_2	0.7	0.8	2.4	1.4
Total flux	2.1	2.4	5.6	6.7
Sp. gr.	1.96	1.96	1.83	2.09
Point at which softening begins under load of 2 kg./cm.^{2}	1450°C	1460°C	1340°C	1420°C
End point	1730°C	1725°C	1570°C	1600°C
P.C.E.	1790°C	1780°C	1730°C	1720°C
Compressive strength room temp.	50	83	133	1024
800°C	74	124	145	892
1000°C	97	218	334	684
1200°C	250	337	183	170
1400°C	53	172	35	27

F.P.H.

Investigation of fired clay mixtures. HERMANN SALMANG AND FLORENZ GOETH. *Sprechsaal*, **62** [28], 503–506; [29], 521–23; [30], 539–43 (1929).—Some of the results

of the investigation are the following: (1) the best results of all series for load under high pressure were always obtained with the mullite ratio (3:2) of Al_2O_3 and SiO_2. (2) Pressure causes forced crystallization by closer approximation of the particles as was proved by mygroscopic slides. (3) The resistance toward temperature change increases with the firing temperature on all mullite mixtures fired under pressure. T.W.G.

Importance of the firing treatment given clay refractories upon the behavior of the material in the load test. HIRSCH. *Tonind.-Ztg.*, **52** [95], 1899 (1928).—A communication from the Chemischen Laboratorium für Tonindustrie, Berlin, discusses the effect of the firing treatment to which several brands of refractories have been subjected, on the behavior of the same refractories in the load test. The results are as follows:

	Coke oven brick		
	Low firing	Normal firing	Refiring at 1400°C
Temp. at which softening begins	1300°C	1410°C	1440°C
Softening temp.	1580°C	1580°C	1580°C
Temp. interval	280°C	170°C	140°C

	Clay refractory	
	Low firing	Refiring at 1400°C
Temp. at which softening begins	1170°C	1340°C
Softening temp.	1600°C	1600°C
Temp. interval	430°C	260°C

F.P.H.

Super-refractory protective coatings. ANON. *Rev. mat. constr. trav. pub.*, No. 236, pp. 109–10B (1929).—The requirements to be met by such coatings are considered. A.J.M.

Influence of impurities on the properties of silica brick. K. ENDELL AND R. HARR. *Rev. mat. constr. trav. pub.*, No. 230, pp. 252–53B (1928).—The conclusions are (1) the percentage of alumina in silica brick should not exceed 1.5%, (2) a percentage of lime below 8% is without influence on the softening point under load and the inversion of quartz to tridymite is facilitated, (3) percentages of iron oxide up to 4% favor the formation of tridymite and are without influence on the softening temperature under load. A.J.M.

Notes on silica brick. R. B. SOSMAN. *Blast Fur. Steel Plant*, **17** [7], 1076–79 (1929).—Certain oxides, including CaO, FeO, MnO, SrO, and ZnO, form with silica "two liquid phases" a phenomenon described by the general term "liquid immiscibility." Alumina and silica in mixtures and combinations such as are found in fire clay make a good refractory up to the temperature of the eutectic 1545°C (2813°F). If the mixture is siliceous, a relatively large amount of liquid is formed at 1545°C and silica dissolves in increasing amounts in this liquid as the temperature rises higher. So far as its thermal equilibrium is concerned, therefore, a siliceous mixture of silica and alumina will fail at a lower temperature than a siliceous mixture of silica and lime. A clay-bonded silica brick is not as refractory as a lime-bonded silica brick. The property of forming two liquid phases, characteristic of the system $CaO–SiO_2$, is quickly wiped out by the addition of only a small percentage of Al_2O_3. The same is true of the alkalis, soda (Na_2O) and potash (K_2O). These form low-melting eutectics with silica, and also with alumina and silica in combination while small percentages of them wipe out the liquid immiscibility shown by lime and silica. We have in these data the fundamental reasons why alumina and the alkalis are avoided, whether in the raw material or in the bond used in making good silica brick. It has been known for some time that clay and feldspar are more troublesome impurities than alkaline earth silicates such as $CaSiO_3$ and $MgSiO_3$, or carbonates such as calcite ($CaCO_3$) and dolomite ($CaCO_3\ MgCO_3$).

The explanation is now at hand from Greig's data and diagrams. The addition of Al_2O_3, on the other hand, to the siliceous ternary mixtures of SiO_2, FeO, and Fe_2O_3 does wipe out the phenomenon of immiscibility just as it does when the addition is made to SiO_2-CaO mixtures. Somewhat more alumina is required, the amount increasing from about 2.7% Al_2O_3 for pure SiO_2-FeO mixtures up to about 6.5% Al_2O_3 when FeO and Fe_2O_3 are present in the ratio 1:1. The practical conclusion is the same for the brick in the open-hearth roof as for the brick in the kiln; Al_2O_3 is an undesirable addition to silica brick for high-temperature service. Here are three facts that may seem rather remotely related to silica brick, and yet may contain a suggestion. (1) Very small grains and very sharp splinters of a crystal have a higher measure of the quality called "fugacity" by the physical chemists than do large grains of the same substance. The fine grains have a higher vapor pressure and a higher solubility than the coarse. (2) A perfect crystal of a hydrated salt will not lose its water under conditions where an imperfect, scratched, or broken crystal will be dehydrated. (3) Quartz has a very imperfect cleavage, breaking conchoidally like a piece of glass rather than along planes of atoms like a crystal of calcite. We may imagine, then, that the crushed quartzite contains fine splinters that evaporate easily or dissolve readily in the calcium silicate at the temperature of the kiln; and that the wavy conchoidal surfaces of even the finest of the broken grains contain many thousands of molecules that are more reactive than the molecules in the body of a sand grain. F.P.H.

Laboratory control methods of General Refractories Co. L. J. TROSTEL. *Chem. & Met. Eng.*, **36** [3], 148–50 (1929); *Trans. Amer. Soc. Steel Treating*, **16** [2], 336 (1929).—The laboratory is a two story brick structure 40 x 55 ft. with a deep basement for storage rooms; fully equipped process laboratory on the first floor and chemical laboratory on the second floor; process of laboratory control is given. E.P.R.

Sampling and testing of refractories in gas undertakings. BENGOUGH. *Gas World; Refrac. Jour.*, **4** [46], 299 (1929).—The proper care of refractories on delivery is discussed. It is preferred that these should be stored between delivery and usage under cover free from contamination from foreign substances. B. points out the vital importance of proceeding too slowly rather than too quickly in drying out, raising heats, and in actual working after the bench has been brought into work. It is especially desirable that there should be no undue haste in gas making and other tests in compliance with the guarantee clauses of a contract. The more that is known of the technology of refractories and of retort bench structures, the clearer it becomes that the dominance of a date is of less importance than the permanent stability of retort settings, using permanence to mean a satisfactory number of years of life with a minimum of repair or reconstructional costs. E.P.R.

Manufacture and applications of refractories. J. F. HYSLOP. *World Power*, **10** [56], 137–44 (1928); *Trans. Amer. Soc. Steel Treating*, **16** [2], 336 (1929).—H. surveys the characteristics of chief refractory materials, silica and silica-alumina, and illustrates main factors which determine their service behavior and use. E.P.R.

Troubles of furnace builders with refractories. ANON. *Refrac. Jour.*, **4** [46], 306–308 (1929).—A need for scientific precision is felt in the refractories field similar to that in metallurgy. Large automatic furnaces involve many considerations other than that of refractories, *e.g.*, conveyers, combustion principles, and automatic controls, but 90% of the troubles are directly due to the refractories. In some cases these furnaces can be built in a manner that will eliminate these refractory troubles but at the expense of good operation and efficiency. Three representative types of installations are (1) underfired normalizing furnaces, (2) enameling furnaces, and (3) brass-melting furnaces. The two primary functions involved in the use of refractory materials are those of thermal insulation and conduction. In some cases the refractory ma-

terial must have considerable strength at high temperatures and in others great strength is unnecessary. The same refractory material has been used both in those positions where a good thermal conductor was required and where a refractory with strength was needed. It is supposed that each refractory due to its own individual properties can be used for certain jobs to better advantage than any other refractory. It is not believed, however, that any one refractory can be best in the hearth, in the side walls, and in the piers. It is almost impossible to tell what a refractory material will do in a given furnace without actually trying it out. The standard tests do not seem to be sufficient. The performance of a given refractory depends, first of all, upon the fuel used in the furnace. The experiments covered in this paper have been confined mainly to the use of oil and gas. It is generally found that a certain type refractory stands up better in an oil furnace than in the gas-fired furnace. Just why this is, is not known. One of the important factors is that small combustion tunnels are used in connection with gas burners. These tunnels consist of refractory materials embedded in the refractory lining. Combustion takes place in these tunnels and the furnace lining is brought up to temperature by the evenly distributed high temperature flue gases. In the oil furnaces combustion is not completed so rapidly and the oil flame seems to glaze the surface, to put a protecting film on the surface of the refractory, thus giving it longer life than can be obtained when gas is used. Present day progress is leading to smaller and smaller combustion chambers. The fact that the furnace atmosphere has an important bearing on the life of the lining is well understood. The fact that silicon carbide must be used at high temperatures in a reducing atmosphere is, of course, well known. This condition is easily handled in many furnaces. The problem of finding a refractory material that is equally satisfactory, that can be used in furnaces in which an oxidizing atmosphere must be maintained, still remains. The fact that metallic vapors from the work in the furnace decrease the useful life of certain refractories when used in the lining is also well known. The part these factors play and the troubles they introduce may be best discussed in connection with concrete examples, a few of which are given in the article. Formerly crucible brass-melting furnaces were lined with a rammed silicon-carbide lining. One of the furnaces was used in melting a copper alloy, half copper and half lead. It was discovered that if lead were first melted in the crucible thus exposing the lining to the action of these lead vapors the furnace could be used then for melting the copper-lead mixture and the lining would last many times as long as a lining which had not had this treatment. The lead melted and evaporated from the crucible seemed to put a protecting surface on the silicon-carbide lining which protected it from further action. It is believed that brickmakers will be able to put a similar glaze on these refractory brick which will protect and lengthen their life. The brass melting furnace offers new problems. In the small crucible furnace a lining is needed that will better withstand the temperature changes that occur with intermittent use, *i.e.*, for operation 8 or 9 hrs. per day. Linings have been developed which have a life of 4000, 5000, 6000, and 7000 heats in furnaces which are operated continuously. Efficiencies of 8, 10, 12, and sometimes 15% for gas and 5, 6, and 8% for oil, are being obtained in general practice at the present time. If we can find a refractory that will stand up, in order that we may fire indirectly, obtaining thermal efficiencies of 20, 25, or possibly 30% we shall have made a real advance over present practice.

E.P.R.

Flat roof vs. curved arch. ANON. *Rev. mat. constr. trav. pub.*, No. 234, pp. 62–63B (1929). A.J.M.

Refractory products in lime and cement kilns. ROBERT LEDUC. *Rev. mat. constr. trav. pub.*, No. 230, pp. 250–52B (1928). A.J.M.

Melting record of three acid open-hearth heats. W. E. GRIFFITHS AND C. E.

MEISSNER. *Trans. Amer. Soc. Steel Treating*, **16** [2], 257–77 (1929).—The paper presents the complete logs of three acid open-hearth heats as made in a 25 T. acid open-hearth furnace. The records show the effect of a change in melting practice, that of adding silicon in the ladle rather than in the furnace. The effect of the various alloy additions on the slag compositions and metal bath analysis is depicted graphically. A discussion of the trends of the various curves is included. E.P.R.

Economic size of the open hearth. F. A. KING. *Mining and Met.*, **9** [264], 550–51 (1928); *Trans. Amer. Soc. Steel Treating*, **16** [2], 334–35 (1929).—Discussion as to how big furnaces can be operated successfully; experience with 300 T. furnaces at Weirton, W. Va., indicates that economic limit has not yet been reached. Paper presented at Open-Hearth Conference, Pittsburgh, Pa. E.P.R.

Manufacture of refractory linings of furnaces. CAMPBELL. *Chem. and Ind.*, p. 457 (1929); *Refrac. Jour.*, **4** [46], 331 (1929).—The lining is formed either of brick or loose material around a core of electrically conducting material the m. p. of which is higher than the fritting point of the lining, the whole being raised to the latter temperature by means of alternating currents in a coil surrounding the furnace, and the core afterwards withdrawn whole. Materials mentioned as suitable for the core are graphite, tungsten, nickle-chrome, and heat-resisting steel. E.P.R.

Silica refractories for carbonizing plants. DALE, SWALLOW, AND WHEELER. Rept. of Refractories Materials Joint Committee. 1929. *Refrac. Jour.*, **4** [46], 332 (1929).—Considerable data is given relating to the after expansion and true specific gravity of silica refractories used in the construction of carbonizing plants. E.P.R.

Refractories for the brass foundry. ANON. *Brass World*, **25** [4], 82–83 (1929).—Prior to gas and oil crucible furnaces, the refractory problem was not serious, the only refractory needed was for the cylindrical lining wall of coal- or coke-fired pit furnaces. There are three refractory problems, exclusive of the crucible; (1) furnace cover; (2) base block; and (3) lining. The furnace cover is subjected to repeated heating and cooling, torsional strains, the highest temperature existing in the furnace, the action of gases at high temperatures, and to velocities. Fireclay covers fail; silicon-carbide type has been the most serviceable. The furnace lining is the most important. Originally it was made of circle fireclay brick, later rammed-in monolithic linings, now a ring type of crucible furnace lining. The lining is made up of 4 or 5 annular rings. The burner and slag holes, and any other openings required are built into the lining in exact position and of proper size and contour. To install the lining it is only necessary to drop the individual rings into their position in the furnace, in the order laid out and marked by the manufacturer. A thin layer of joint cement is spread on each ring. The lining can be put into operation immediately and the average time for the complete installation, from the start until the heat is turned on, is about 1 hr. The linings are made of super-refractory materials. When the carbon type is used, clearance is allowed between the lining and the furnace shell for filling with insulating material in powdered form. E.P.R.

Refractories for gas retorts. FRED A. HARVEY. Amer. Refrac. Inst., *Tech. Bull.*, No. 29 (1929).—The discussion is an attempt to apply the chart entitled "Utility of Refractories" to the particular use of the refractories in coal-gas benches. The effect of the following factors on the life of gas-retort refractories is discussed in detail: (1) abrasion, (2) slagging, (3) spalling, and (4) melting. In a gas retort we deal with coal and coke inside the retort, and producer or coal gas as a heating medium outside the retort. The retorts are horizontal, inclined, or vertical. The speed with which the charge moves is very low in the vertical retort, while in the inclined and horizontal types the speeds are zero until the retort is drawn or pushed, and for this short period of time the speed is fairly rapid. The pressure, on the other hand, is considerably greater at the

bottom of the vertical retort than in the horizontal, except in the case where some coke rolls under and around the pusher head when the ram is pushed into and withdrawn from the horizontal retort. The "hardness" of the coke varies considerably with the nature of the coal mixture and coking period. In general, the coal as charged would not be regarded as hard, while the coke is hard and of a nature to cause considerable abrasion. The sharp angles of the coke particles make them strongly effective as abrasive agents. The factor, "character of joints" refers to workmanship, design, and type of mortar; the number of joints and their width may have considerable influence. There is in gas-retort practice a strongly abrading material moving at a low or medium speed, according to type of retort; usually moderate pressure; with good workmanship and design of joints, the other factors are unimportant. Slagging is not important in the gas retort, except as scurf is considered as a slag, but it is important in the producers. Spalling is not a serious factor in the retorts if proper space for expansion is provided and proper heating and cooling schedule followed. It may be an important factor in the producers and end retort brick, particularly for horizontal and inclined retorts. For the retort walls a refractory is required which has good resistance to abrasion, mechanical spalling, and melting, with very high rigidity at high temperatures and high thermal conductivity. The other factors are of less importance. In the supporting structure, resistance to melting, *i.e.*, high refractoriness and rigidity, is of importance. The end brick must be able to withstand mechanical and thermal spalling and greater abrasion, while rigidity and thermal conductivity are of less importance. In the gas producers, abrasion, slagging, mechanical, structural, and thermal spalling are of greater importance. In addition, high insulating properties resulting in confinement of heat are desirable. F.P.H.

Heat exchange in regenerators. H. HAUSEN. *Zeit. Ver. deut. Ing.*, **73** [15], 431–33 (1929); *Trans. Amer. Soc. Steel Treating*, **16** [2], 335 (1929).—Mathematical analysis of heat exchange in regenerators and recuperators; derivation of formula of efficiency of regenerators. E.P.R.

Calculation of regenerators based on heat-transmission coefficient. K. RUMMEL. *Stahl und Eisen*, **48** [49], 1712–15 (1928); *Trans. Amer. Soc. Steel Treating*, **16** [2], 335 (1929).—Attempt is made to calculate certain important values of regenerators according to formulas for recuperators, degree of temperature fluctuation during adjustment period, influence of brick thickness, and general recommendation for design. E.P.R.

Theory and applications of regenerative principles in the steel industry. II. T. J. MCLAUGHLIN. *Blast Fur. Steel Plant*, **17** [7], 1044–47 (1929).—A review of the principles of heat recovery through regeneration in the heating equipment in steel plants is discussed with reference to checker construction and operation. For Part I see *Ceram. Abs.*, **8** [8], 586 (1929). F.P.H.

Chemistry of open-hearth operations. C. H. HERTY, JR. *Blast Fur. Steel Plant*, **17** [7], 1034–38 (1929).—The reactions that occur in the basic open-hearth process are complicated. This paper gives practical applications of the principles involved. F.P.H.

Open-hearth combustion process is regulated mechanically. G. A. MERKT. *Iron Trade Rev.*, **84** [14], 914–15 (1929); *Trans. Amer. Soc. Steel Treating*, **16** [2], 335 (1929). Details of Isley furnace control apparatus applied to open-hearth furnace; Venturi tubes equipped with motor-driven fans eject furnace gases and supply draft in definite proportions; duplex arrangements of Venturi tubes; no moving parts exposed to high temperatures. E.P.R.

Investigation of economy of different decarburizing media for open-hearth furnace practice. S. SCHLEICHER. *Stahl und Eisen*, **49** [14], 458–64 (1929); *Trans. Amer. Soc. Steel Treating*, **16** [2], 335 (1929).—Based on result of refining tests, it is shown that

oxygen content of refining medium has no influence on velocity of melting down of charge; silicic-acid content of refining medium plays important rôle. E.P.R.

Influence of dust deposits on efficiency of checkerbrick regenerators. A. SCHACK. *Arch. Eisenhüttenwesen*, **2** [5], 287–92 (1928); *Trans. Amer. Soc. Steel Treating*, **16** [2], 335 (1929).—Discussion of damage due to dust and slags of poor conductivity on brick of checkerwork regenerators, and how injurious effects can be calculated; effect of dust deposit is made evident by increase of average difference of temperature of brick surface in heating and coal period, and consequent drop of heat transmission coefficient. E.P.R.

Refractories. SWALLOW. Rept. of Refractories Materials Joint Committee, 1929. *Refrac. Jour.*, **4** [46], 332 (1929).—A discussion of the influence of oxidizing and reducing atmospheres on refractory materials. Reducing atmospheres have been found to set up unequal strains in furnace structures. E.P.R.

Determination of gas penetration on refractories. A. KANZ. *Stahl und Eisen*, **49** [26], 941–42 (1929).—A review of the work done by Wologdine, Wickerham, Westman and Pfeiffer, Easter, and Bansen is given. T.W.G.

Experimental data on the equilibrium of the system iron oxide-carbon in molten iron. A. B. KINZEL AND J. J. EGAN. *Mining and Met.*, **10** [272], 390 (1929).—This paper describes a method of determining the FeO-C equilibrium constant, which gives consistent results. The data indicate that 5×10^{-4} is the value of M at 1550°C and one atmosphere pressure, which is considerably lower than has hitherto been supposed, but the results are remarkably consistent and independent of initial concentrations. It is surprising that carburization of the metal does not take place in the presence of CO; in one case decarburization takes place. The authors suggest that this is probably to be explained by the CO-CO_2 equilibrium, with deposition of C on the cold walls of the container. The order of magnitude of M does not change with temperature within the limits of usual steel-making practice. If the new value is substantiated, the current idea on the mechanism of open-hearth reactions must be modified, and the changes in the concepts of the physical chemistry of steel-making which it connotes are discussed. F.P.H.

Characteristics of refractory clays for the glass industry. G. GEHLHOFF, H. KALSING, K. LITZOW, AND M. THOMAS. *Glastech. Ber.*, **6** [9], 489–531 (1928); *Jour. Soc. Glass Tech.*, **12**, 213–79, 280T (1928).—For abstract see *Ceram. Abs.*, **8** [8], 586 (1929).

Stalactites in a tank furnace at the Welikodworer Glassworks. B. S. SCHWEZOW. Tech. Science Div. d.O.V.W.R., No. 59, *State Exptl. Inst. Silicates* [U.S.S.R.], No. 16, pp. 5–8 (1924); *Glastech. Ber.*, **4**, 438 (1927).—Stalactites up to 37 cm. long found depending from a furnace crown had the composition:

	(1)	(2)	(3)	(4)
SiO_2	88.38	91.85	91.22	90.0
$Fe_2O_3 + Al_2O_3$	2.75	2.40	2.02	2.16
Mn_2O_3	0.70	0.90	1.07	2.09
CaO	2.20	2.90	3.27	4.39
MgO	0.20	Trace	0.27	0.14
Na_2O	5.77	1.95	2.15	1.29

Comparison with the analysis of the silica brick showed that the compositions were similar except for the alkalis and manganese derived by volatilization and as fine dust from the glass and batch. No crown drops were found in the glass after the furnace was cooled down. (*J.S.G.T.*)

Refractory material used in glass industry. FRANZ KANHÄUSER AND JOSEF ROBITSCHEK. *Tonind.-Ztg.*, **52** [92], 1840–42; [93], 1858–61; [94], 1881–83 (1928).—The following subjects are discussed: (1) use of silica brick in the glass industry, (2) chemi-

cal composition of various kinds of clay refractories used in the glass industry and physical properties of the clays which are used in making these refractories, and (3) requirements of refractories used in the glass industry. F.P.H.

Sagger production. WILHELM BACHER. *Keram. Rundschau*, **35**, 256–57 (1927).—Types of clay and of grog used in saggers, methods of preparing and mixing raw materials and forming the saggers, and methods of preventing common defects are described briefly. Two recommended sagger compositions are given. H.I.

The porcelain industry. I. MARC LARCHEVÊQUE. *Rev. mat. constr. trav. pub.*, No. 222, pp. 56–59B (1928).—The Dorst process (screw press) for making saggers is described and illustrated. Other types of sagger presses are described. **II.** *Ibid.*, No. 223, pp. 77–80B.—The grinding and glazing of rounds and the glazing of saggers are discussed. The grinding machines of Faure, Charbonnier, and Haviland are described and illustrated. **III.** *Ibid.*, No. 224, pp. 105–108B.—L. discusses the finishing of glazed saggers. **IV.** *Ibid.*, No. 226, pp. 160–63B.—Discussion of sagger presses is continued. **V.** *Ibid.*, No. 227, pp. 179–82B.—Discussion of saggers is continued. A.J.M.

Argillaceous and siliceous materials and products. I. P. RENAULT. *Rev. mat. constr. trav. pub.*, No. 225, pp. 137–41B (1928).—Refractory sands (quartzose sands) and materials for luting saggers are discussed. **II.** *Ibid.*, No. 226, pp. 157–60B (1928).—Compositions of various mixtures for luting saggers are given. Plasticity is discussed. **III.** *Ibid.*, No. 227, pp. 182–86B.—The use of materials for the protection of saggers in the vicinity of fireboxes is discussed. Refractory brick, mortars, and thermal insulators are considered. **IV.** *Ibid.*, No. 228, pp. 209–13B.—The fashioning of strips of luting material is discussed with considerable theory being given in regard to hydraulic pressure. **V.** *Ibid.*, No. 229, pp. 231–34B.—R. discusses friction in regard to pressing clay bodies and mixtures. **VI.** *Ibid.*, No. 230, pp. 256–60B.—Plasticity is discussed. **VII.** *Ibid.*, No. 231, pp. 278–82B.—Different types of auger and piston machines for forming strips of luting material for saggers are described. **VIII.** *Ibid.*, No. 232, pp. 16–19B (1929).—Pistons and augers are discussed. **IX.** *Ibid.*, No. 233, pp. 38–44B.—Uses of the Archimedean screw in sand washers, etc., auger machines, roll crushers, disintegrators, etc., are discussed. **X.** *Ibid.*, No. 234, pp. 57–60B.—Piston apparatus is treated. Types of screw and of blade apparatus are discussed. **XI.** *Ibid.*, No. 235, pp. 89–91B.—Cutting of columns of clay as they leave pug mills, auger machines, etc., is treated. **XII.** *Ibid.*, No. 236, pp. 110–14B.—Different types of apparatus for fabricating strips of luting material are described and illustrated. A.J.M.

Heat-insulating brick. DALE AND WHEELER. Rept. of Refractories Materials Joint Committee, 1929. *Refrac. Jour.*, **4** [46], 331 (1929).—The matters dealt with include the effects of temperature on commercial heat-insulating bricks, temperature distribution in walls, location of insulating blankets, thermal economy, and structural stability. E.P.R.

A light weight insulating brick. ANON. *Brit. Clayworker*, **38** [447], 142(1929).—The invention of a Swedish mining engineer, Ivar Setterberg, is based on the same principle as the so-called gas concrete. The brick are only $^1/_2$ as heavy as ordinary fire brick, but contain 3 times greater insulative properties. Among other qualities are porousness, resistance to high temperatures, and great mechanical solidity. For their production a finely ground powder of fireproof materials such as fire clay, chamotte, china clay, quartz, flint, magnesite, dolomite, ferrochrome, or alundum is mixed with water to form a plastic mass. Materials that develop gas when mixed with water, such as aluminum, calcium, zinc, or carbide, are mixed with the paste and allowed to ferment. Brick are then made, dried, and fired at about 1300°C. Owing to the development of gas during the process, a large number of pores are formed and by special methods developed by the inventor these pores are made permanent. During firing the brick acquire a structure resembling

pumice stone. The specific gravity of the brick is about $^1/_2$ that of ordinary fire brick produced from the same clay. R.A.H.

Industrial treatment of Moler earth. ANON. *Rev. mat. constr. trav. pub.*, No. 223, pp. 73–75B (1928).—Moler earth is an impure variety of kieselguhr in which the siliceous diatoms are mixed with clay. The only known deposits occur on two Danish islands. The material is used as a heat insulator. A.J.M.

Kieselguhr and its importance. MAX BERGER. *Tonind.-Ztg.*, **53** [2], 25–26 (1929).—The various applications of kieselguhr are described. F.P.H.

Diatomite industries incorporated. ANON. *Refrac. Jour.*, **4** [46], 332 (1929).—International Diatomite Industries, Ltd., Montreal, Ont., Can., has been incorporated with a capital of 110,000 shares with no par value. E.P.R.

Uses for asbestos. ANON. *Cement, Mill & Quarry*, **34** [8], 32 (1929).—Asbestos is one of the most important fireproofing materials known. E.P.R.

Refractory mortar. ANON. *Blast Fur. Steel Plant*, **17** [7], 1075 (1929).—High-temperature cements may be made from pulverized, fired fire clay in the form either of waste (scrap) refractories or calcined fire clays having similar chemical composition to the refractories. In using the waste refractories care must be taken not to use that portion which may have fused glass or slags attached to its surface as this will lower the refractoriness of the mortar. Most of this waste refractory, however, is usually free of this fused material. By adding a colloidal material, such as bentonite or aquacryptite, a suitable refractory mortar may be obtained at a minimum cost. This cement will be satisfactory if the present lining is suitable, since additions of this type of material only lower the fusion range sufficiently to vitrify the joint at the furnace temperature. This high-temperature cement may be mixed with coarse grog to make a monolithic lining in various types of furnaces. F.P.H.

Dolomitic clinker as a stable basic refractory. M. E. HOLMES, W. J. MCCAUGHEY, AND G. A. BOLE. *Rock Prod.*, **32** [15], 59–67 (1929).—Properties, development, uses, and commercial scale production of stable dolomite clinker are discussed. The purposes of the laboratory phase of this investigation were to define the limits of the stable field employing the oxides of iron, aluminum, and silicon as fluxes and to determine, if possible, the optimum petrographic structure for a stable clinker. By a stable clinker is meant one which will neither dust nor slake. Slaking is caused by hydration of free lime. Dusting is caused by the conversion of β to γ dicalcium silicate, and usually occurs as the clinker cools (critical temperature 675°C). Slaking presents no manufacturing difficulties but limits the use of the product. Dusting makes impossible the manufacture of the clinker. Several tests were tried for determining stability. The one used by Robson, Withrow, and Bole was finally adopted. The procedure consisted of introducing weighed specimens into an autoclave containing water, heating to 320°F in 1 hr., cooling in 10 min., and determining the extent of slaking in terms of the percentage of the sample that would go through a 10-mesh screen. This procedure was repeated as as often as necessary, the results being expressed in per cent slaking per heat. These data roughly fix the boundaries of the stable field. The other data necessary for precisely fixing the boundaries were then determined and all of it assembled in the triangular chart. This chart is the upper portion of a very much larger one, the apices of which represent dolomite, mill scale, and sand. Only that portion representing more than 80% dolomite is used. The chart brings out the point that the stabilizing agent is the silica. The silica must be between the limits given, but the iron oxide may be present in any amount. A chart for the alumina–silica–dolomite system showed stable and unstable areas practically identical with that given for the iron–silica–dolomite system. Substituting alumina for the iron oxide, therefore, gives substantially identical results insofar as the stability relationships are concerned. This further emphasizes the point that

silica is the stabilizing medium and that either iron oxide or alumina may be used singly or together, but neither iron oxide nor alumina may be substituted for silica, their functions being to make possible the reaction between the lime and silica, whereby stabilization is effected. It is not to be understood that all clinkers in the various fields are equally stable or unstable. In the slaking field, points of relatively less instability are found corresponding, perhaps, with eutectic compositions. In the dusting field there is much less variation, as all compositions are more nearly completely unstable.

F.P.H.

Silicon carbide as refractory material. F. NIEBLING. *Tonind.-Ztg.*, **53** [12], 227–28 (1929).—The properties of SiC are enumerated and the advantages of this type of refractory are pointed out. These refractories have a high thermal conductivity, great resistance to abrasion, and high load-bearing qualities, but are not very resistant to basic slags. The following results are given from some SiC-clay-sand mixtures.

	I	II	III
Composition	9 parts SiC 1 part clay	8 parts SiC 1 part sand 1 part bond clay	7 parts SiC 2 parts sand 1 part bond clay
Firing	Cone 13	Cone 13	Cone 13
Softening point under load of 2 kg./cm.^{2}	1860°C	1820°C	1765°C
Melting point	1980°C	1920°C	1825°C
Sp. gr.	2.3	2.2	2.1

F.P.H.

Bauxite in 1928. ANON. *Clay-Worker*, **92** [1], 41 (1929).—The production of bauxite in the U.S. during 1928 was 375,426 long tons, valued at $2,273,898. This is an increase of 17% in quantity and 14% in value as compared to 1927. Ark. was the heaviest producer and showed more gains than any other section. Other important producing sections were Ga., Ala., and Tenn. Of the bauxite produced, about 68% was used in the abrasive industry, 26% in the chemical industry, and 6% in the aluminum industry. The exports of bauxite, including concentrates, amounted to 112,984 T. E.J.V.

Zirconium dioxide as refractory material. RUFF AND EBERT. *Zeit. anorg. allgem. Chem.*, pp. 19–40 (1929); *Refrac. Jour.*, **4** [46], 331 (1929).—This is a contribution on the application of highly refractory materials in the ceramic industry with special reference to zirconium dioxide. It is claimed that by adding a small amount of magnesium oxide to the zirconium dioxide and heating to about 1400°C a product is formed which does not change on cooling and is serviceable for operations involving widely different ranges of temperatures. Calcium oxide may be substituted for the magnesium oxide.

E.P.R.

Quarrying ganister near Mt. Union, Pa. ANON. *Rock Prod.*, **32** [15], 46–48 (1929).—The unusual rock products operation of the Harbison-Walker Refractories Co. at Mt. Union, Pa., are described. Ganister is the name given to a certain kind of silica rock which resembles ordinary white sandstone to a marked degree, except that it is considerably harder and more crystalline in structure. The microscope shows ganister to consist of a mass of interlocking crystals of silica. Sandstone, on the other hand, consists of silica sand grains, usually rounded. The deposits were no doubt laid down originally under conditions that resulted in a silica or siliceous material of unusual purity being formed, and subsequent metamorphic action altered this stone, giving it properties that make it so highly desirable for use in the manufacture of refractories. Later the softer adjacent rock was eroded, leaving this harder siliceous material as a broken, shattered residue. F.P.H.

Zettlitz kaolin. ANON. *Ber. deut. keram. Ges.*, **9** [12], 618 (1928); *Refrac. Jour.*, **4** [46], 332 (1929).—The application of Zettlitz kaolin as a refractory material is dis-

cussed and the results recorded of standard tests carried out on the material. Detailed chemical analyses and physical tests are given. E.P.R.

Madagascar graphite. ANON. *Rev. mat. constr. trav. pub.*, No. 223, pp. 90–91B (1928).—The first researches were made in the region of Tananarive by León Suberbie in 1904. Graphite is found nearly everywhere in Madagascar but is most abundant in the provinces of Antsirabe, Betafo, Ambositia, Fianarantsoa, Tananarive, and in the regions of Tamatave, Maramanga, Vatomandry, Mananjary, and Farafangana. While the graphite of Ceylon is taken from mines, that of Madagascar is removed by open cuts, the benches being 2.5 to 3 m. wide and 2 m. high. The following data are given on the production:

Year	Production (Metric tons)	Exports
1913	7,997	6,300
1914	11,232	7,749
1915	15,940	11,851
1916	26,524	25,480
1917	35,000	26,945
1918	16,000	14,622

The exports in 1926 were 11,454 metric tons as follows: France, 5257; England, 4292; Germany, 690; U.S., 770; other countries, 445. A.J.M.

Use of chromium as a refractory. ANON. *Brick Clay Rec.*, **75** [3], 160 (1929).—As chromium may be used for the preservation of many metals, it becomes evident that any uses which rapidly dissipate chromium should be eliminated. A relatively large amount of chromite is consumed as a refractory. In order to find a substitute for this dissipating use it is necessary to find a refractory having the following physical and chemical properties: (1) resistance to chemical reaction with fused metals, slags, vapors, etc.; (2) resistance to deformation caused by a wide range of temperatures; (3) strength to withstand loads, blows, shocks, etc., in wide range of temperatures; (4) thermal conductivity; (5) durability; (6) uniformity; (7) resistance to erosion, spalling, etc.; (8) capability of conforming to accurate measures when molded. E.J.V.

Chrome ores in the world's commerce. JAMES RUBINFELD. *Metallwirtschaft*, **39**, 1929; *Refrac. Jour.*, **4** [46], 298–99 (1929).—The great producing centers for chrome ores are Rhodesia, Cuba, New Caledonia, and Greece. Steel-making concerns have lately sought to control their own sources of chrome ore, a notable example being the Bethlehem Steel Corp. of the U.S. which takes the whole of the Cuba chrome ore production. In 1913 the world production of such ores was estimated at 177,532 T. The Rhodesian production alone reached about 210,000 T. in 1927, out of a total world production of about 360,000 T. The U. S. consumption is about 55% of the latter figure. E.P.R.

A new refractory material (Wetamaterial). A. KARSTEN-SALMONY. *Korrosion*, **4**, 17 (1929).—"Weta" is suitable as a porcelain and quartz glass substitute for laboratory apparatus. It is made of powdered SiC mixed with silicates and certain metals. It resists acids, alkalis, temperature shock and is not easily broken. (*C.A.*)

Contributions to the ceramics of highly refractory materials. II. The system: zirconia–lime. OTTO RUFF, FRITZ EBERT, AND EDWARD STEPHAN. *Z. anorg. allgem. Chem.*, **180**, 215–24 (1929).—Study of the melting-point diagram of the system: ZrO_2–CaO reveals two eutectics, containing respectively 30 and 60 mol. % ZrO, and the compound $CaZrO_3$. X-ray Debye-Scherrer photographs verify the existence of this compound and also show that CaO and ZrO_2 form mixed crystals with a CaO content varying from 0 to 40 mol. %. Evaluation of the Debye diagrams gives to the compound a monoclinic structure, closely bordering on the cubical, $\beta \sim 89°$. The density calculated from these data is $d_r = 4.74 \pm 0.05$, which agrees very well with the value obtained pycnometrically, $d_p = 4.78 \pm 0.05$. Chemical analyses not only verify the existence of

$CaZrO_3$, but prove that no vaporization of CaO takes place on fusion. The differences between the systems: ZrO_2–CaO and ZrO_2–MgO are readily explained by consideration of the size relationships which obtain among the ionic radii of the three cations involved (Ca^{++} = 1.06, Zr^{IV} = 0.93, Mg^{++} = 0.78 A. U.). (*C.A.*)

Refractories and boiler furnace linings. REGINALD TRAUTSCHOLD. *Paper Trade Jour.*, **88**, [17], 56–60 (1929). (*C.A.*)

PATENTS

Flexible anchor. JOHN E. ANDERSON. U. S. 1,720,875, July 16, 1929. In anchoring means, an anchoring member of substantially V-shape and of open construction, the member having an angularly disposed finger at its apex, the arms of the anchoring member being adapted for coöperation with means for anchoring the same to a wall.

Air-cooled furnace wall. DAVID S. JACOBUS. U. S. 1,720,958, July 16, 1929. In a furnace, a wall of refractory material having on its outer side material substantially impervious to air, a casing outside the wall and spaced therefrom, and means to connect the wall and casing constructed and arranged to permit relative movement between the wall and the casing in their respective planes, and means for introducing air into the space between the wall and the casing.

Recuperator and tile structure therefor. WALTER O. AMSLER. U. S. 1,721,938, July 23, 1929. A recuperator made up of tile each having a body portion with a passageway therethrough and lateral flanges projecting from its sides near the ends of the body portion, the tile being built into columns and fitted directly together to form vertically extending passages therethrough and horizontally extending passages therebetween.

Furnace lining. LLOYD R. STOWE. U. S. 1,723,092, August 6, 1929. A furnace lining comprising spaced parallel frame members, brick of substantially standard firebrick dimensions arranged in courses extending transversely of the frame members, the brick being arranged in pairs between adjoining frame members and having notched sides adapted to engage the frame members, the brick of each pair having notches of different depths, and the brick being so engaged with the frame members that the shallower-notched brick alternate with the deeper-notched brick in directions longitudinal and transverse of the frame members.

Use of dumortierite. JOSEPH A. JEFFERY AND FRANK H. RIDDLE. U. S. 1,723,174, August 6, 1929. A batch for a ceramic material, comprising dumortierite.

Ventilated brick construction. RALEIGH J. HIMMELBRIGHT. U. S. 1,723,650, August 6, 1929. A refractory brick channeled to afford, when built into a refractory furnace structure, a U-passage from the exterior of the structure inward toward its inner surface and out again to its exterior, such passage comprising pairs of inward extending channels cross-connected in multiple.

Soaking-pit furnace. SAMUEL G. WORTON. U. S. 1,724,058, August 13, 1929. The combination with a soaking-pit furnace having the usual pits provided with brick bottom and side walls and a centrally arranged slag hole opening through the bottom wall, of a semi-permanent refractory lining on the bottom of the pits and extending upwardly along the side walls thereof, the lining having its bottom wall inclined toward the slag hole so as to permit the slag to flow from the pit by gravity, the slag hole being normally closed at its lower end by a removable closure and filled to a point above the level of the lining with a granular filling material.

Furnace-roof construction. JOHN DOUGLAS MACKENZIE AND RICHARD W. SENGER. U. S. 1,724,098, August 13, 1929. A block adapted to form a portion of a furnace roof comprising a metallic casting having radiating fins extending downwardly therefrom to substantially the inner surface of the roof, the fins of material having high heat conductivity being suitably spaced to permit the insertion of refractory tile therebetween and to conduct heat from the inner surface of the tile to the casting.

Smelting furnace. HENRY L. CHARLES. U. S. 1,724,340, August 13, 1929. In a reverberatory smelting furnace having vertically extending side and end walls and a roof, cooling means located adjacent the firing end, comprising a plurality of hollow brick laid in the roof and in the walls contiguous to the roof, each brick being open at one end and closed at the other, the closed ends providing inner peripheral portions of the furnace and the open ends extending exteriorly thereof, a metallic container mounted within each brick, a cold water main, a hot water header pipe, and means for operatively connecting the main and pipe with each container.

Saggers. A. HEATH AND H. COLCLOUGH. Brit. 312,794, July 24, 1929. A frame of cardboard or other material which is destructable by heat is inserted within a sagger for use in firing pottery. The frame may be formed of corrugated material, and in addition to the frame a cone or pyramid of combustible material may be disposed in the center of the sagger and in the space between each tier of articles.

Bricks for regenerators, etc. J. H. JACK. Brit. 313,226, July 31, 1929. A packing-brick for heat-exchange apparatus or reaction and absorption spaces, has parallel non-intersecting ribs extending entirely across two opposite sides, the other sides being flat.

Aluminium oxide. VEREINIGTE ALUMINIUM-WERKE AKT.-GES. Brit. 313,409, August 8, 1929. The molten slag containing aluminium oxide and sulphide obtained by subjecting a mixture of bauxite and a sulphur-containing material such as pyrites to a reducing smelting process, for instance with coal, is chilled before its solidification, as by a current of gas or steam or by being passed into water or being delivered onto a cooled or moving iron plate or into a cooled rotating drum or into a liquid metal, such as aluminium, of lower specific gravity than the melt. By this means the oxide is obtained in a fine state of division.

Terra Cotta

Lepidolite in cone 6 terra cotta glazes. HARRY E. DAVIS. *Jour. Amer. Ceram. Soc.*, **12** [9], 570–71 (1929).—The following study was undertaken to discover what possibilities might lie in the introduction of Li_2O into the RO of a terra cotta glaze, using lepidolite.

Special depth gage for measurement and control of ceramic coatings. A. LEE BENNETT. *Jour. Amer. Ceram. Soc.*, **12**, [9], 572–76 (1929).—A depth gage is described whereby the thickness of ceramic coatings on any piece of ware may be determined regardless of its shape or surface.

Notes on terra cotta glaze consistency. H. SPURRIER. *Jour. Amer. Ceram. Soc.*, **12** [9], 577–80 (1929).—Some of the difficulties encountered in applying glaze to terra cotta are discussed. The use of a hydrometer to test glazes is misleading as a hydrometer supplies gravity indication only in true solutions and glazes are not true solutions, furthermore, the viscosity of a glaze may obscure the real specific gravity. It is suggested that in order to control a glaze it should first be made to a desirable specific gravity and then the desired viscosity at that gravity be ascertained by experiment. A viscosimeter and specific gravity bottle are suggested for this purpose. The effect of change of alkalinity and of bacteria together with the control of glaze wastage are also discussed.

Effect of particle size of zinc oxide on the consistency of glaze slips. H. G. THOMSON. *Jour. Amer. Ceram. Soc.*, **12** [9], 581–84 (1929).—No brand of oxide on the market is known to T. which does not have to be calcined to obtain satisfactory results in glazes, and it is further noted that a small amount of PbO present in the various grades is an essential constituent for satisfactory calcination. Microscopic examination showed an increase in particle size after calcining, although differences in uniformity of size and shape existed. The effect of zinc oxide in glaze slips was found to be dependent on its particle size and shape. Therefore, the control of consistency of a glaze is simplified by

the use of a properly calcined zinc oxide, by which a higher gravity and a more thinning range are obtained.

Clay deposits (for tiles) of French Flanders. GEORGES DUBOIS. *Rev. mat. constr. trav. pub.*, No. 236, pp. 97–101B (1929). A.J.M.

A defect in glazed and engobed stoneware. MAURICE HAUSSONNE. *Rev. mat. constr. trav. pub.*, No. 222, pp. 59–61B (1928).—H. deals with the defect which is caused when the engobe and glaze pull away from the body where the latter has sharp curves and angles. The problem is one of five variables, three of them being the coefficients of expansion of the glaze, engobe, and body, and two being the shrinkages of the body and engobe. The causes and remedies are discussed in detail. A.J.M.

Pavement tile and vitrified brick of stoneware. ANON. *Rev. mat. constr. trav. pub.*, No. 231, pp. 277–78B (1928).—The following operations are involved in the manufacture: (1) grinding of clays, fluxes, non-plastics; (2) intimately mixing the ingredients by the wet, dry, or pasty method, with addition of specially ground coloring agents; (3) drying of the plastic bodies formed by the wet and pasty methods; (4) grinding of the dried bodies to the powder or dust form (containing about 5% water); (5) pressing the dust into shape by a pressure of 250 kg. per cm.^{2}, a small amount of oil having been added to the dust; (6) drying the tile and firing them to about 1300°C. A.J.M.

Durability of architectural terra cotta and faience. W. A. MCINTYRE. *Brit. Clayworker*, **38** [447], 132–XIV (1929).—A résumé is given of Building Research Special Report No. 12. It is shown in the experimental section of this report that the porosity of terra cotta is so low as to be negligible, and the modern highly finished or glazed surface tends to prevent entirely the absorption of rain-water. The blocks are not called upon to carry heavy or point loads. It would seem therefore that filling is valueless as a constructional feature, and its cost and weight preferably eliminated. The report is illustrated with a number of photographs showing examples of failure from one cause or another. The report describes the experimental work carried out in the laboratory for the purpose of elucidating the causes of decay and failure. R.A.H.

Stone vs. terra cotta. ANON. *Brick Clay Rec.*, **75** [3], 156–58 (1929).—Chicago has recently been the scene of a most interesting battle waged by a prominent local newspaper, the *Chicago Tribune*, between clay products and an aggressive competitor, stone. The battle is recounted in detail since it reveals a technique in merchandising which the clay products industry should study. E.J.V.

Flowerpot manufacture. ANON. *Brick Clay Rec.*, **75** [4], 212–16 (1929).—Flowerpot manufacture, at one time undoubtedly one of the crudest operations to be found in the clay industry, has been elevated to a position of efficiency which ranks with the best. The use of ultra-modern equipment in the manufacture of flowerpots in the plant of the Florence Pottery Co. of Mt. Gilead, Ohio, was completed and put into operation within the past year. Some of the revolutionary features of this plant are a Diesel engine, tunnel kiln, humidity drier, and machinery of the most modern type. While these features are not revolutionary as far as the clay industry as a whole is concerned, they are quite startling when considered in connection with a product like flowerpots, which has never attained a ranking place in the industry. The kiln is a gas-fired, muffle-type tunnel kiln, 150 ft. 8 in. long and has 24 trucks, each having a loading platform of 6 ft. x 3 ft. 8 in. with a loading height of 3 ft. 3 in. The plant equipment is described in detail. E.J.V.

PATENTS

Glazed brick and tile. J. P. BILBIE. Brit. 313,766, August 8, 1929. Sand and lime brick and tile are provided with glazed and color effects upon certain sides by the application of dry oxide colors and then a coating of transparent cellulose varnish. The sides are first prepared by a material, such as lime, which fills the pores and makes a

ground for the application of the colors. Any desired number of colors may be applied in order to produce the desired effect and the cellulose varnish may be applied by spraying. White effects in an umbrated pattern may be produced by applying the cellulose coating directly to the prepared surface. According to the Provisional Specification a coating of sodium silicate is applied to the color layer prior to the application of the cellulose coating.

White Wares

Effect of water in expanding ceramic bodies of different compositions. H. G. SCHURECHT AND G. R. POLE. *Jour. Amer. Ceram. Soc.*, **12** [9], 596–603 (1929).—The effects of the composition of some ceramic bodies on their moisture expansions were investigated. With the exception of mixtures containing blast-furnace slag or magnesite, most bodies with high absorptions developed considerable expansion. Bodies with low absorptions composed of pure clay and feldspar developed practically no moisture expansion while those composed of clay, feldspar, and more than 20% silica developed considerable moisture expansion. By adding magnesite, the resistance of a ceramic body to moisture expansion was improved. Additions of whiting, iron oxide, and titanium oxide were not as beneficial as magnesite. It was found that crazing caused by moisture expansion of bodies can usually be prevented by proper manufacturing control.

Effect of chemical composition of glazes on their thermal expansion and annealing temperature. R. RIEKE AND E. KUNSTMANN. *Ber. deut. keram. Ges.*, **10** [4], 189–229 (1929).—Six base glazes are used in the investigation and the effect of varying the following three factors: (1) type and amount of RO, (2) Al_2O_3, and (3) SiO_2, on the above-mentioned properties are studied. The effect of the various oxides on the fusion point of the various base glazes is discussed. These glazes were later applied to porcelain bodies and fired to cones 14, 15, and 16 and the resistance to crazing was determined by a series of quenchings. The results are summarized in part as follows: (1) Na_2O has the greatest effect on increasing the thermal expansion of the glaze. Na_2O also has a greater effect in lowering the viscosity and annealing temperature than K_2O. The replacement of large amounts of CaO by K_2O results in a considerable increase in viscosity. The fusion point of Na_2O glazes is much lower than similar glazes with Na_2O replaced by K_2O. (2) The replacement of small amounts of CaO by MgO has very little effect on the thermal expansion and annealing temperature of the glazes; however, large substitutions greatly reduce the coefficient of expansion and raise the annealing temperature. The viscosity at the softening temperature decreased with small additions of MgO, but increased after a certain MgO-content was attained. Similar observations were made in the case of the fusion point. (3) The coefficient of expansion decreases considerably when BaO is introduced in the place of CaO. The addition of large amounts of BaO raises the annealing temperature and the viscosity. (4) A very great reduction of the coefficient of expansion was obtained when ZnO was introduced into the glaze. (5) The coloring oxides CoO and Cr_2O_3 greatly reduces the coefficient of expansion and Cr_2O_3 has a much greater effect than CoO. From a comparison of the thermal expansion measurements and the results obtained in the quenching tests it can be stated that the coefficients of expansion of the glaze and body are the most important factors in glaze fit.

F.P.H.

Action of sulphur compounds on glazes. ANON. *Tonind.-Ztg.*, **53** [1], 9 (1929).—Action of sulphur compounds present in the kiln gases on the surface of glazes is discussed.

F.P.H.

Glazing of unfired semi-porcelain sanitary ware. M. PHILIPP. *Keram. Rundschau*, **35**, 237–39 (1927).—The substitution of single-fire ware for two-fire ware effects economies in the industry that enable German manufacturers to meet foreign competi-

tion. In changing from production of two-fire to single-fire ware changes are especially necessary in compositions, in glazing procedures, and in drying methods. During the firing it is necessary, especially at higher temperatures, that the raw glaze has a shrinkage corresponding to that of the body. Crazing and flaking of the glaze result from the use of unsuitable glazes. Only completely dried, unfired ware may be safely glazed by dipping. The glaze slip should be dense and viscous. The addition of an organic colloid which is burned out during firing, such as gelatine or dextrin, makes the glaze more adhesive. Cleansing of the glazed ware is best done immediately after dipping rather than after the piece is partially dry. Proper drying is necessary before setting in the kiln. Twenty-four hours at from 25 to 30° is usually satisfactory. If storage space permits, longer drying periods often give better results. The proper firing of the kiln is important. With round kilns much depends on the judgment of the fireman but with tunnel kilns having good temperature measuring devices the necessary changes in firing are soon made. In general, the single-fire method as compared with the two-fire method (1) increases ware losses somewhat, and (2) reduces firing costs. The introduction of a bonus system for operators in the casting, firing, setting, and glazing departments tends to reduce operating costs. H.I.

Soldering metals to porcelain. ANON. *Brass World*, **25** [5], 112 (1929).—The Westinghouse Electric and Mfg. Co. solders metals to porcelain by a process which gives a joint that is stronger than porcelain, and so tight against air and liquid pressure that it will hold a high vacuum. Being metallic, the joint will not take up water, and being a good conductor, it equalizes insulating stresses on the porcelain near it, thus often increasing its actual insulating value. Successful application, though simple, requires skillful and experienced technique, and operators must be carefully trained. E.P.R.

220,000-volt one-piece transformer bushing. J. WALLICH. *Ceram. Ind.*, **13** [2], 179 (1929); *Keramos*, **8** [25], T3, 879 (1928).—A problem which called for long and extensive experience in firing technique consisted in the manufacture of a 220 000-volt transformer bushing of one piece of porcelain. Special machines were designed to cope with the exceptional dimensions of this large insulator. After being fired, the one-piece porcelain product was to be about 9 ft. high, of 2.6 ft. inside diameter and with a thickness of wall tapering from about 2 in. to 1.18 in. Considerable difficulties had to be overcome to eliminate shocks during the transport of the sensitive and bulky piece from turning shop to kiln for firing, for in spite of its thin walls, the bushing weighs 2200 lbs. in the finished state. F.P.H.

Causes of cracking of plate tile during manufacture. ANON. *Rev. mat. constr. trav. pub.*, No. 223, pp. 75–76B (1928). A.J.M.

Manufacture of ceramic tile. ANON. *Rev. mat. constr. trav. pub.*, No. 234, pp. 53–55B (1929). A.J.M.

Manufacture of mosaic tile. ANON. *Rev. mat. constr. trav. pub.*, No. 223, pp. 83–85B (1928). A.J.M.

Research on floor tile. H. K. BOHR. *Keram. Rundschau*, **35**, 161–62 (1927).—Floor tile made by dry-press methods are compared with those made by wet methods as to chemical composition, true and apparent porosity, capillary action and hardness. The dry-press tile are at least equal to those made by wet methods in all respects. H.I.

New U. S. testing machine for chinaware. ANON. *Pottery Gaz.*, **54** [626], 1285 (1929).—A modified impact machine for chinaware has been designed and constructed to obviate certain difficulties encountered in the use of the similar testing machine specified in the U. S. Government Master Specification for Vitrified Chinaware, No. 243a. The modified type machine has only one steel cylindrical hammer, weighing 5 oz., and

suspended by eight piano steel wires. Because of its manner of suspension, this pendulum swings in a vertical plane in an arc having 24-in. radius, thus eliminating one of the objectionable features of the specified machine. One face of the new hammer is a spherical surface used to make impact tests, while the other is a cylindrical surface used to make chipping tests. A steel scale graduated in divisions representing fractions of a foot-pound is fastened to the supporting frame at the lower end of the arc through which the pendulum swings. A comparative study of the specified and modified machines showed there was practically no difference in the values obtained with either machine. E.J.V.

Impressions of American potteries. ANON. *Pottery Gaz.*, **54** [626], 1294 (1929).—The members of the Ceramic Society of England who recently visited America shared in a tour which was a slight taste of American hustle. That there was much to see and a good deal to learn is everywhere admitted, but, as far as domestic pottery is concerned, the lasting impressions appear to be those which had reference to the large-scale methods upon which things are done in America, and the lengths to which potters in the U.S. are prepared to go in the efforts to achieve standardization. The differences in the cases of American and British potteries are pointed out, as to market for ware, type of ware most in demand, etc. E.J.V.

Story of an American pottery. ANON. *Pottery, Glass & Brass Salesman*, **40** [1], 11–12 (1929).—The growth, during the active business life of one man, of a little four-kiln pottery to the world's largest manufacturer of chinaware, is the dramatic story of the Homer Laughlin China Company, of East Liverpool, Ohio, and Newell, W. Va., as told in "Cross Section," issued by Ferguson Engineers in July. E.P.R.

Plants of the W. S. George Pottery Co. ANON. *Ceram. Ind.*, **13** [2], 153–56 (1929). F.P.H.

Making of Japanese pottery. A. R. PRESTON. *Commerce Repts.*, No. 32, pp. 411–13 (1929).—The making of pottery is one of the oldest industries of Japan. Its designs were copied by other countries in the 18th Century, but the establishment of modern factories for the commercial production of Japanese pottery is a comparatively recent development. This quantity production, enhanced by decorative design in which the Japanese artist excels, enables the country to compete as one of the world's principal manufacturers and exporters of fine ceramics. A brief description of the process of manufacture in the largest and most up-to-date porcelain factory in Japan is given. This factory employs about 2600, and operates 26 kilns, of which 2 are tunnel and 3 single-decorating kilns, one of the tunnel kilns being oil-fired and one single-decorating kiln being heated with electricity, while the rest are coal-fired. It is the plan of the company to install electricity in the tunnel kilns in the near future. E.J.V.

Importation of ceramic tile into Chile. (Industrial note.) ANON. *Rev. mat. constr. trav. pub.*, No. 226, p. 167B (1928). A.J.M.

Tile industry in Holland. (Industrial note.) ANON. *Rev. mat. constr. trav. pub.*, No. 229, p. 238B (1928). A.J.M.

Porcelain industry in Czechoslovakia. ANON. *Rev. mat. constr. trav. pub.*, No. 231, p. 286B (1928). A.J.M.

PATENTS

Apparatus for testing the dielectric strength of insulating material. ARTHUR O. AUSTIN. U. S. 1,721,847, July 23, 1929. Apparatus for testing insulators comprising terminal members for impressing test voltages on an insulator at the sides thereof, a conductor spaced from one of the terminal members for supplying charging current to the insulator at a distance from the place of application of the test voltages and a dielectric covering for the conductor, the conductor being free from attachment to the insulators being tested to permit ready application of the testing apparatus to different insulators.

Sanitary cove for floor coverings. DONALD S. CONNELLY. U. S. 1,722,660, July 30, 1929. A cove including faces adapted for abutment against floor and wall faces, faces providing an interlocking engagement for the side edges of a floor covering, and a cove face, a floor abutment face and an interlocking engagement face forming a securing flange for connection with a floor, and an interlocking engagement face and the cove face forming a tongue overlapping the edge of a floor covering engaged by the interlocking engagement faces.

Electric suspension insulator. OTTO BECKER. U. S. 1,722,887, July 30, 1929. A suspension insulator comprising an insulating body having an outwardly inclined abutment surface and a unitary cap placed over the body and extending over the inclined surface, wedge-shaped holding pieces inserted between the cap and the insulating body, the wedge-shaped pieces lying on the inclined abutment surface, registering circumferential grooves on the inside surface of the cap and the outer surface of the holding pieces, and flexible members in the grooves.

Means for diverting energy from conductors. ARTHUR O. AUSTIN. U. S. 1,723,000, August 6, 1929. The combination with a conductor having a break therein, of a jumper connecting the portions of the conductor at opposite sides of the break, the jumper being formed into a coil having its axis extending in the direction of the conductor to form the primary of a current transformer and a secondary winding for the current transformer disposed so that the magnetic field of the primary interlinks with the secondary winding.

Porcelain shelf bracket. CHARLES H. CHAMBERLAIN AND CHARLES TSCHUDIN. U. S. 1,723,408, August 6, 1929. In porcelain shelf brackets, a tapering bracket, a flanged base integral therewith, a sub-base extending beyond the bracket base, an undercut projection extending rearwardly from the sub-base, the projection having a dove-tail groove on its inner face, and a plurality of small grooves on the undercut edges of the projection.

Electric insulators. ASSOCIATED ELECTRICAL INDUSTRIES, LTD. Brit. 311,658, July 10, 1929. A high-voltage insulator, formed with an upper mounting member and a lower clamp for carrying a conductor is provided with electrostatic field control devices in order to avoid the formation of flashover arcs. Each device is of U-section, with thin sides and is formed with crescent or toroidal ends giving extensive end surfaces. The devices are each riveted to carrying members which are constructed to have minimum conducting surface. The lower members are connected to a yoke by screws, the upper members having their inner portions close together so as to be secured by screws. Where it is desired to prevent the formation of arcs, the metal parts at the ends of these lines are constructed of reduced area.

Electric insulators. F. BERG. Brit. 312,205, July 17, 1929. An insulator for taking up tension forces in live wire suspensions consists of a cylindrical rod or porcelain, etc., provided with circumferential ribs and is characterized by the fact that the ribs are drawn downward to form "rain noses." Metal caps are secured on the ends of the rod by means of cement or a metal filling.

Firing glazed tiles. W. R. BROAD, A. E. LOVATT, AND G. G. PETRIE. Brit. 313,026, July 31, 1929. A kiln box for use in firing bull-nose and similarly curved glazed tiles has a flat surface portion and a depressed portion for supporting the main part and curved end, respectively, of the tile, and the base of the box is hollow and arranged so that a number of boxes may be disposed in a stack. A short projection is provided in the depression for supporting the end of the tile above the base of the depression, and surplus glaze is collected either in the space below such projection or in a groove formed in the bottom of the depression. One or more tile may be adapted to be supported side by side in a single box, an appropriate number of depressions being provided.

Molding pottery, etc. MORGAN CRUCIBLE CO., LTD., AND C. W. SPEIRS. Brit. 313,185, July 31, 1929. Articles are cast or molded in a perforated mold by applying pressure to liquid slip, preferably through a flexible diaphragm, the surplus liquid being expelled through the perforations in the mold. In some cases the mold may have the dimensions and configuration of the completed article. In a modification of the latter apparatus the walls of the article to be produced are cast or molded onto a preformed plastic base member, and the mold is split longitudinally into two halves. In another construction the article produced has a narrow neck like a flask, and the core collapses sufficiently to be withdrawn through the neck.

Casting ceramic articles. A. O. AUSTIN. Brit. 313,325, July 31, 1929. Ceramic articles are produced by depositing slip about a yielding core adapted subsequently to be removed from the formed article. The core, which is of a definite shape, may comprise a central support and a covering of yielding material.

Electric insulators. BROWN, BOVERI ET CIE AKT.-GES., ABTEILUNG INSTALLATIONEN. Brit. 313,540, August 8, 1929. In suspension insulators as described in the parent specification, the expanding members which support the bolt in the insulator cavity are provided on the faces abutting on the ledge of the cavity with a covering of relatively soft material such as lead. This covering is preferably formed of a small plate, the edges of which are turned up against the sides of the members and may be applied by laying an annular plate against the bearing faces of the members and cutting open the intervening parts by radial incisions. The members and the connecting ring which is preferably circular in section may be made of malleable cast iron, and may be cast integral with the bolt. A sleeve maintains the members in their operative position and is retained by hooks formed on depending arms thereon.

Equipment and Apparatus

Recording pyrometers. C. B. GORDON-SALE. *Mech. World*, **86** [2219], 29–30 (1929).—Owing to the severe service conditions under which pyrometric recorders have to operate, it is of paramount importance that they be constructed as ruggedly, simply, accurately, and reliably as possible. Most modern instruments fulfill these requirements and are rapidly being improved. While recorders operated by resistance or radiation may be encountered, usually only those designed to work with thermoelectric couples are installed. Of the latter, three principal types are employed; (1) drum, (2) roll, and (3) disk. Outside of laboratory work, where recorders working on the potentiometric principle are used for transformation point determinations, nearly all recorders are fitted with galvanometers. Temperature readings are given by a pen or pointer, as the case may be, operated by the electrical circuit from thermocouple to galvanometer. The chart is operated by a clock mechanism which by means of cams deflects the pen or pointer at regular intervals onto the chart and records an indelible impression. A description of each type of recorder is given. E.P.R.

"Pyrophot" a new radiation pyrometer. F. HIRSCHSON. *Keramos*, **8** [12], T7, 455–58 (1929).—A description is given of a new radiation pyrometer manufactured by Paul Brown and Co. of Berlin-Reinichendorf-Orst. F.P.H.

Pyrometer controller with mercury switch. ANON. *Ceram. Ind.*, **13** [2], 198 (1929).—Whereas most electric pyrometer controllers make use of open contacts and require a relay for controlling electrical loads of any magnitude, the new instrument made by the Republic Flow Meters Co., incorporates a mercury switch. The switch is capable of carrying current up to 10 amp. and may, for instance, be used in controlling electric furnaces up to $3^1/_2$ kw. capacity. F.P.H.

A recording photo-electric color analyzer. ARTHUR C. HARDY. *Ceram. Ind.*, **13** [2], 158–63 (1929).—The instrument described in this paper was designed for the rapid

measurement of the color of reflecting surfaces, a problem which is now of considerable importance in many branches of science and industry. F.P.H.

Microscope for Brinell tests. ANON. *Brass World*, **25** [4], 91 (1929).—The new mechanism is known as the Busch-Schumann projector-type microscope for Brinell hardness-testing machines. The image of the Brinell ball impression, even when a lipped rim is produced, appears at once magnified ten times and sharply focused on a ground-glass screen as soon as the instrument is set up in the spot to be measured so that the measurement can be read immediately and without trouble, with both eyes and with great accuracy; moreover the result, unlike that obtained with lens and measuring microscope, appears with even edges and without any focusing. E.P.R.

Automatic sample collecting vacuum pump. E. R. WEAVER AND M. SHEPHERD. *Jour. Amer. Chem. Soc.*, **50** [7], 1829–35 (1928).—A pump is described which has been in successful operation for several years. It is an automatic Töpler which acts as a backing unit to a high speed mercury vapor pump. The mercury is automatically returned to the cycle while the gas pumped is automatically collected and may be transferred as desired to other units. The control system is entirely independent of the vacuum pump and may find other applications in which alternating vacuum and pressure are desired. R.G.M.

Handling clay with drag scraper. ANON. *Brick Clay Rec.*, **75** [4], 234 (1929).—A system of clay handling in and out of storage that is efficient and economical is in use by Golding Sons Co., Trenton, N. J. This system will prove of interest particularly to those manufacturers who ship in clay and to those who maintain storages for weathering purposes. Perhaps of all the features in connection with the installation, the most noteworthy is its simplicity. The system consists essentially of a scraper bucket, cables, hoist, and blocks, and requires practically no attention. One man, from his position 15 ft. above the hoist, has a view of the entire operation, and performs all the necessary work. E.J.V.

Whirlwind pulverizer. ANON. *Blast Fur. Steel Plant*, **17** [7], 1061 (1929).—This improved impact-attrition pulverizer has been operated on many different materials with success. Ores, limestone, hydrated lime, coal, coke, resins, and analogous materials are reduced to a uniform fineness in many cases without the need of air separation. A heavy, vertical, chrome-nickel forged shaft supports three steel disks upon which are firmly bolted heavy chrome-nickel alloy hammers. Each disk with its set of hammers revolves in its individual pulverizing chamber, which consists of a corrugated alloy breaking ring, concentric with the disk. Each chamber is separated from the adjoining chamber by corrugated ledge plates both at the top and bottom. A horizontal shaft transmits rotation to the vertical shaft through spiral bevel gears, the ratio of which may be made to accommodate motor, turbine, or belt drive. The case is vertically split for accessibility. All bearings are heavy duty, self-aligning with individual oil pumps. Material up to $1^1/_2$ in. size is fed in at the top of the machine and discharged in a very uniformly pulverized state. Due to the construction details, the pulverizer itself acts as a separator and holds back all materials until they reach the desired fineness. F.P.H.

Hammermill for crushing wet material. ANON. *Brick Clay Rec.*, **75** [4], 234–36 (1929).—The most advanced type of Williams Patent Crusher & Pulverizers Co.'s hammermill equipment is a mill for crushing of wet, muddy material. The material entering the hopper is pushed into the path of the hammers by two flat, reciprocating, piston-like rams, the downward motion of which scrapes the breaker plate clean and forces the rock and mud into the crushing radius. The outstanding advantage of this improved hammermill is that it will crush to $^3/_4$ in. and finer (when so adjusted) continuously. E.J.V.

A hammermill without screens. A. KARSTEN. *Chem. Fabr.*, No. 28, p. 325 (1929).—For materials tending to pack, a hammermill is recommended which uses curved plates and no screens, the size of grain being determined by the length of the plate (a fine grain requiring a long plate and a coarse grain a short plate) and adjustments in the space between the ends of the hammers and plate. The outside of the mill is shown.

T.W.G.

A survey of research on rock crushing. EDMUND SHAW. *Rock Prod.*, **32** [15], 70–75 (1929).—A basic theory of crushing was worked out by the slow and careful methods of the laboratory where every condition could be controlled. Gross and Zimmerley studied the relation of measured surface to sieve-mesh sizes, and in doing this brought out certain facts which explain the difficulties and the false conclusions of earlier investigators. These are (1) that the interior surface, the surface in cracks and irregularities, is at least as great as the theoretical surface, figured from the diameter of the grain, and (2) that the amount of interior surface, in proportion to the theoretical surface, increases with the size of the piece in a very regular way. F.P.H.

Dust and fume exhaust systems. ANON. *Brass World*, **25** [6], 136–37 (1929).—The choice of a dust or fume collector depends on the amount of recovery percentage desired; the value of the recovered material; whether the dust-producing operations are continuous; risk of nuisance complaints from the neighbors; the danger in the nature of the collected material; and the initial and operating cost of the installation. The cyclone type collector is useful mainly for recovering large, hot, or highly abrasive dust. It operates on the centrifugal principle. For high efficiency, it is necessary to use some positive method of filtering and arresting the dust. In the "Norblo" cloth screen arrester, which has an efficiency of over 99% recovery, the filtering screens are contained in a sheet steel case. In order to maintain proper filtering capacity it is necessary to shut down the arrester every few hours to shake off from the screens the accumulation of dust which has collected upon them. There are various ways of doing this.

E.P.R.

Screening plant for dry materials. C. H. S. TUPHOLME. *Mech. World*, **86** [2218], 12–15 (1929).—The simplest type of screening machine is the long perforated cylinder. The perforations in a revolving screen will give a product of smaller size than the perforation. The difference in the size of stone that will pass given size ring (by hand) and the same size hole in a revolving screen is due to the angle of the screen-plate where the stone passes through. The sizes of product may be estimated according to the following table:

Size of cube, (in.)	Size of ring, (in.)	Size perforation in revolving screen (in.)
1/4	3/8	1/2
1/2	5/8	3/4
3/4	7/8	1 1/8
1	1 1/4	1 1/2
1 1/4	1 1/2	1 7/8
1 1/2	1 7/8	2 3/8
1 3/4	2 1/4	2 3/4
2	2 1/2	3
2 1/2	3	3 1/2
3	3 3/4	3 7/8
3 1/2	4 1/2	5 1/2

The vibrating screen has come very much into use. It is efficient for the screening of almost any material. Many of the different types of screens and their constructions are described. Insufficient attention is usually paid to the efficiency of a screening device. This should be an important consideration in purchasing since inefficient separation often results in an over-loading of the grinding circuit with material already of sufficient fineness. Material requiring screening into two products may be separated into over-

size and undersize, the particles in the latter being of a dimension permitting passage through the screen apertures if given free opportunity, and the particles in the former being larger than the apertures. Where the operation of sizing is being performed by a mechanical appliance such as the vibrating screen, it is possible to estimate the efficiency of separation expressed in per cent as follows: Let A = total tonnage of undersize in feed and a = total tonnage of undersize in product.

$$\text{Efficiency of separation} = \frac{100a}{A}.$$

Without data on tonnage, or in cases where the screen is in closed circuit with secondary crushers, the efficiency of separation may be determined by making screen analyses of the feed and the coarse product. Thus, if T = tons of feed, t = tons of coarse product, O = % of oversize in feed, o = % of oversize in coarse product, U = % of undersize in feed, and as ot must equal OT, therefore $t = \frac{OT}{o}$.

$$\text{Tons of fine product} = T - t = T - \left(\frac{OT}{o}\right),$$

$$\text{Tons of undersize in feed} = U\,T,$$

$$\text{Efficiency of separation} = \frac{100\,T\,(o - O)}{o\,U} \div \frac{U\,T}{100} = \frac{100\,T\,(o - O)\,100}{o\,U\,T},$$

$$\text{hence } \frac{10{,}000\,(o - O)}{o\,U} = \%\text{ efficiency}.$$

E.P.R.

Clay plant clinic. ANON. *Brick Clay Rec.*, **75** [4], 224–27 (1929).—The Evens & Howard Fire Brick Co., St. Louis, Mo., has a clay plant clinic established for the purpose of rehabilitating worn and broken down equipment. It serves the same purpose for industry as a clinic would for human beings; when a piece of equipment is not performing efficiently it is taken to this department, examined for its trouble and then treated until it is back into normal shape and ready to work efficiently again. Among the achievements of this clinic are listed repairing of tunnel kiln cars, repairing of a furnace on a tunnel kiln without decreasing production, annealing of thermocouples, installation of a cold junction box system on the kilns, and an interesting car puller arrangement.

E.J.V.

Chromium plating in the blown, pressed-glass industry. KURT ILLIG AND WALTER BIRETT. *Ceram. Ind.*, **13** [2], 170–76 (1929).—In galvanic chromium plating a metallic chromium layer is deposited on the parts inserted as the cathode from a chromium compound (mostly chromic acid) by aid of the electric current. For the electrolyte, depending on the requirements which are to be placed on the coating, solutions with 200 to 500 g. chromic acid (CrO_3)/1, to which small quantities of sulphuric acid or other catalyzers are added are used. The hexavalent chromium ions liberated from CrO_3 through the dissociation, give their charges to the cathode and are reduced to metal through the trivalent chromous stage. Under normal conditions the content of the solution in trivalent chromous ions remains, therefore, practically constant as in the unit of time just as many Cr(3) ions are discharged to metal as are formed by reduction from Cr(6) ions. Besides the Cr ions the hydrogen ions of the solution participate also cathodically in the electric transversion and to such an extent that about 80% of the entire energy falls to the development of gaseous hydrogen and only 20% of the energy used to the precipitated metal. Under an increase in temperature and unfavorable composition of the bath, and also by faulty operating method, this relation displaces itself also in disfavor of metal precipitation and decreases the output very considerably. If the tension is too

low, then the reduction stops at the trivalent stage of the chromium and leads only in a subordinate measure to a metal precipitation. The cathode material also plays an important rôle. The greater the over-voltage of the hydrogen ions the more favorable are the conditions for the precipitation of the chromium which like zinc can best be precipitated from acid solution tanks to the over-voltage of the hydrogen at its surface. From this it follows naturally that the cathodic properties of the ground coat metal, even when only at the beginning of the precipitation, are of great importance.

F.P.H.

PATENTS

Spray gun and spray head therefor. GEORGE WILLARD BRYANT. U. S. 1,722,892, July 30, 1929. In a spray gun, the combination of a body having a passage therethrough for liquid and a passage therethrough for air, an inner nozzle fixedly mounted on the body and communicating with the liquid conducting passage, an intermediate nozzle rotatably mounted on the body and in constant communication with the air body passage and surrounding the inner nozzle and spaced therefrom and having spaced lateral ports, an outer nozzle rotatably mounted on the intermediate nozzle and having a plurality of supplemental air outlets and having leading to the outlets, ports which are adapted to be in or out of register with the ports in the intermediate nozzle according to the relative position of the intermediate and outer nozzles, means for holding the intermediate nozzle and the outer nozzle in desired position relative to each other and to the body and interengaging loose-motion stop means on the intermediate and the outer nozzles adapted to stop relative rotation of the intermediate and outer nozzles with the supplemental air ports thereof in register when rotation is had in one direction and to stop relative rotation of the parts with the ports out of register when rotation of the parts is had in the reverse direction.

Drier for ceramic ware. HALVER R. STRAIGHT. U. S. 1,724,325, August 13, 1929. A drier comprising side walls, end walls, and a top to form a drier chamber, partitions arranged adjacent to the inner face of the side walls to form vertically arranged compartments, each of the compartments being provided with an inlet opening at its lower end and an outlet opening at its upper end, heating coils extending longitudinally through each set of compartments, means for conveying ware through the drier between the compartments, the conveying means being provided with transversely arranged passages designed to communicate with vertically arranged passages in the ware stacked thereon, a fan in each of the openings in the upper end of the compartments, the fans being independently operated, means for introducing a drying medium in one end of the drying chamber, and the chamber being provided with an outlet opening in its opposite end.

Tile dies. A. SANT AND W. BOULTON, LTD. Brit. 313,015, July 31, 1929. Relates to dies for producing undercut recesses in tile backs by the use of a rubber shaping-member and comprises a plunger, fitted with a rubber shaping-member which is projected above the die during compression and is withdrawn by a spring flush with, or slightly below the surface of the die during ejection to permit the molded tile to be pushed forward off the die.

Kilns, Furnaces, Fuels, and Combustion

Calculation of firing costs for round kiln operation. OTTO TIPPMANN. *Keram. Rundschau*, **35**, 208–209 (1927).—Methods of calculating costs are given. H.I.

Heat distribution in firing periodic kilns. CARL LOESER. *Sprechsaal*, **62** [31], 559–62 (1929).—A series of figures are given, pronounced as standard and obtained on six firings under average conditions with round and rectangular kilns. The average coal consumption for 100 kg. ware in the round kiln is 24.7 kg. and in the rectangular kiln 23.7 kg. The heat balance of the six firings averages as follows:

	Round kiln	Rect. kiln
Ware	32.7	31.3
Masonry and loss during firing	19.7	22
Combustion gases	47.5	46.7

T.W.G.

Utilization of waste heat in periodic kilns. ANON. *Rev. mat. constr. trav. pub.*, No. 222, pp. 65–66B (1928). A.J.M.

Water-cooled tunnel kiln firing tile. ANON. *Brick Clay Rec.*, **75** [3], 144–49 (1929).—These kilns are equipped with water-cooling coils on the sides and top of the kiln and extending about 30 ft. over the cool end of the kiln. Distillate oil is used as fuel and the kilns all fire from cone 017 to cone 18. The tunnel kilns of the McDougal type, are 150 ft. long, divided into 5 zones; the preheating zone about 39 ft. long with a flat arch, the firing zone of 35 ft. with an arch having a radius of 5 ft., the indirect air-cooling zone 29 ft. long with a flat arch, the water-cooling zone 28 ft. long. and the direct air-cooling zone 18 ft. long. The methods of production of the tile are described in detail. E.J.V.

Use of fuels in tunnel kilns. W. E. RICE. *Clay-Worker*, **92** [1], 26–34 (1929).—R. deals with the use of fuels in continuous heating furnaces of the railroad-car tunnel type, which at present provide the most efficient means of heat-treating such materials as metallurgical products, steel sheets, carbon electrodes, brick, tile, pottery, etc. R. discusses three things in particular: (1) various fuels, gas, oil, and coal; (2) movements of the gases in the various zones of the kiln; and (3) the confinement of products of combustion in muffles when accurate control of atmosphere is required as in the case of many high-grade metallurgical and ceramic products. E.J.V.

Causes of the diminution of yield of continuous kilns. L. DEVILLER. *Rev. mat. constr. trav. pub.*, No. 224, pp. 97–99B (1928).—The causes are summarized as follows: (1) lack of length of combustion space, (2) dampness of the kiln bottom and the kiln foundations, (3) lack of tightness of the masonry, (4) poor draft due to short stack and poorly proportioned flues, (5) too much moisture in the products being fired, (6) bad arrangement of ware in the kiln, (7) bad firing and lack of experience of the fireman, (8) bad closing of the ports and openings, and (9) inferior quality of combustible. A.J.M.

Watersmoking and preheating in circular kilns. P. THOR. *Rev. mat. constr. trav. pub.*, No. 229, pp. 217–19B (1928). A.J.M.

Firing brick in continuous annular kilns. ANON. *Rev. mat. constr. trav. pub.*, No. 231, pp. 273–75B (1928). A.J.M.

Drying brick in a continuous kiln. ANON. *Rev. mat. constr. trav. pub.*, No. 233, pp. 31–32B (1929). A.J.M.

Utilization of heat from cooling chamber. ANON. *Rev. mat. constr. trav. pub.*, No. 232, pp. 13–14B (1929).—The heat should be used for water-smoking if other sources of heat are available for drying. A.J.M.

Utilization of waste heat from continuous kilns. ANON. *Rev. mat. constr. trav. pub.*, No. 233, p. 30B (1929). A.J.M.

Progress of fire in curved portions of kilns. ANON. *Rev. mat. constr. trav. pub.*, No. 236, pp. 101–102B (1929). A.J.M.

Shrinkage rod and its uses. ANON. *Brit. Clayworker*, **38** [447], 140–41 (1929).—Of the various methods of ascertaining the progress of the firing of a brick kiln, one of the simplest consists in measuring the shrinkage of the contents. The method of using the shrinkage rod is described. If the firing shrinkage of the material is known, a steel measuring rod may be inserted through a suitable opening in the top of the kiln until it reaches the brick inside and the distance may be measured from the top of the brick to the top of the kiln arch. The firing is continued until this distance becomes equal to that

deemed necessary from previous experience. Underfiring of brick in certain portions of the kiln should be eliminated by changing the setting of the brick to cause the fire to travel in such direction as to overcome this feature. R.A.H.

Gas-fired glost kiln saves in labor, sagger losses, and repair costs. J. B. NEALY. *Ceram. Ind.*, **13** [2], 158 (1929).—Recently one of the glost kilns of the Buffalo Pottery Co., formerly fired with coal, has been converted to gas firing and to the down-draft type. It was found that the labor incident to coal and ash handling, fire stoking, and cleaning, was eliminated by the use of gas, and it was unnecessary to seal against sulphur fumes. The only wadding required was to make a support for the saggers. The sagger loss was reduced materially and there was a considerable saving in kiln repairs and fuel. It was stated that saggers last 10% longer in the gas-fired kiln. F.P.H.

Mathematical fundamentals of firing stoneware. W. SCHUEN. *Tonind.-Ztg.*, **53** [9], 168–70 (1929).—A method of determining kiln efficiency is described. Various fuels are compared. High-volatile coal is preferred for firing stoneware. F.P.H.

Use of powdered coal in firing whiteware. ANON. *Keramos*, **8** [12], T2, 461–64 (1929).—This subject is discussed by a number of ceramists. Powdered coal as a fuel is compared with other types of fuels. F.P.H.

Advantages of clarified low-gravity fuel oils. WILLIAM WIGHT. *Glass Ind.*, **10** [8], 185–86 (1929).—Authentic details are given as to the satisfactory results obtained in a well-known glass plant through the installation of a centrifuge. Clarified fuel oil not only gives maximum service in the heating of the melting tank or furnace but eliminates foreign matter from the fuel, which tends to diminish the occurrence of defects in the finished product. E.J.V.

Utilization of lignites in brick and tile plants. ANON. *Rev. mat. constr. trav. pub.*, No. 235, pp. 81–82B (1929). A.J.M.

Oxidizing neutral and reducing firings. ANON. *Rev. mat. constr. trav. pub.*, No. 235, pp. 81–82B (1929). A.J.M.

Maintenance and repair of kilns. ANON. *Rev. mat. constr. trav. pub.*, No. 231, pp. 272–73B (1928). A.J.M.

Interpretation of stack gas analysis. G. E. SALKVIST. *Blast Fur. Steel Plant*, **17** [7], 1055–57 (1929).—It is explained how, by determining the amount of CO_2 and O_2 in the waste gas from combustion, deficiencies in fuel utilization may be calculated in terms of CO. F.P.H.

Bunsen flames of unusual structure. FRANCIS A. SMITH AND S. F. PICKERING. Bur. Stand., *Jour. Research* [Rept. No. 84], **3** [1], 65–74 (1929).—A mixture of air or oxygen with a combustible gas is forced through a cylindrical burner tube, and the flame is observed as it burns in secondary air. The number of sides to flames is a function of the size of the burner tube and of the composition of the gas mixture. Twenty photographs of flames are presented and discussed. R.A.H.

Design of high-pressure gas pipe lines. RALPH E. DAVIS AND LYON F. TERRY. *Gas Age-Rec.*, **64** [4], 103–107 (1929). F.P.H.

Iodine pentoxide apparatus for carbon monoxide in flue gas. F. E. VANDAVEER AND R. C. GREGG. *Gas Age-Rec.*, **64** [5], 137–39 (1929).—Iodine pentoxide has been used for determining concentrations of carbon monoxide for many years. Many of the methods and apparatus used heretofore have been developed for certain particular problems and differ essentially in the system used for purifying the gas before passing through the iodine pentoxide, the temperature to which the iodine pentoxide is heated, the manner of purging the system, and the method of determining the amount of carbon monoxide present. The iodine pentoxide apparatus described may be used successfully for routine analysis of carbon monoxide in concentrations as low as 0.002% in the prod-

ucts of gaseous combustion when (1) carbon dioxide, oxygen, hydrogen, methane, ethane, hydrogen sulphide, sulphur dioxide, nitrogen, and oxides of nitrogen are present in small quantities, (2) formaldehyde is present in less than 1% if one chromic acid tower is heated to 100°C. Correct readings cannot be secured where relatively large quantities, 0.04 to 1.9%, of ethylene are present in the products of combustion.

F.P.H.

Measurement of gas temperatures up to 1500° in radiation fields of variable anisotropy. H. SCHMIDT. *Arch. Eisenhüttenwesen*, **2** [5], 293–99 (1929); *Trans. Amer. Soc. Steel Treating*, **16** [2], 335 (1929).—Functions of gas temperature measurement; expansion of measuring range up to 1500°C; measurement of radiation of thermocouple through hot walls; improvement in design of gas pyrometer; measurement of gas and air temperature in chambers of open-hearth furnace; and optical measurement and recording are discussed. E.P.R.

Complete gasification of coal for town gas. MORRIS TRAVERS. *Jour. Soc. Chem. Ind.*, **47**, 203T; **47**, 214T (1928).—The principles involved in the economic production of water-gas and details of a new plant designed and patented by T. are given and discussed. The results obtained on a commercial scale from three plants which have been erected are also given. (*J.S.G.T.*)

Bussey process of low-temperature carbonization. DAVID BROWNLIE. *Gas Age-Rec.*, **64** [5], 141–42 (1929). F.P.H.

Furnaces for heat treatment of metals. ANON. *Brass World*, **25** [2], 32 (1929).—The annealing temperature of aluminum is very close to its melting point. The temperature of the furnace must be exact, and the temperature gradient between heat source and work, iow. A very large area of heating surface is worked at low wattage per sq. ft. Control is obtained by pyrometers which actuate control contractors through low-energy industrial-heating relays operating on unusually small temperature differentials. Individual teeth made by the dentist are baked, glazed, and stained in a furnace having a heating chamber 3 in. deep by 2 in. wide by 1 in. to the place where the curved roof starts to be pronounced. The overall dimensions are $6^1/_2$ in. wide across the legs by 7 in. long by $7^1/_2$ in. high. It is rated 500 watts, 110 volts, and reaches a temperature of 1960°F. Only one tooth is baked at a time. The full temperature is attained in 26 min. This tiny furnace, operating on 110 volts, is intended for use by the individual dentist, and is being produced at the rate of 500 a month. E.P.R.

BOOKS

Low-Temperature Carbonization, or Distillation Explained. MURRY STUART. London Mining Publications, 1929. 57 pp. Reviewed in *Mining and Met.*, **10** [272], 20 (1929).—An experienced gasworks' chemist discussed briefly and non-technically the aims of low-temperature distillation and the principles on which the industry is founded. S. aims especially to emphasize the danger of attempting to generalize from any particular case, and the need for investigation before installing or investing in any process. The history of the process, its principle, and scope are set forth. Directions for calculating whether the process can work profitably are given, and the types of processes are explained. F.P.H.

Cleaning of Coal. W. R. CHAPMAN AND R. A. MOTT. Chapman and Hall, London, 1928. 680 pp., illus., diagrams, tables. Reviewed in *Mining and Met.*, **10** [272], 20 (1929).—An exhaustive work on coal cleaning. The history, practice, and economics of coal cleaning are discussed, methods of testing and controlling washers are explained, and the various methods of cleaning now in use are described fully both from the theoretical and practical aspects. The authors have particularly in mind the promotion of cleaning in the British mines, and have prepared this treatise to call attention to the possibilities of all methods in use. F.P.H.

PATENTS

Electric furnace. FRANCIS A. J. FITZGERALD. U. S. 1,714,081, May 21, 1929. An electric furnace for heat-treating substances having a resistor chamber containing an inert atmosphere, a heat-treating chamber containing a gas having a pyrochemical and physical action on the substances heat treated and a septum between the chambers that will not deteriorate when heated to a high temperature and subjected to a reducing atmosphere within the resistor chamber and a gas having a pyrochemical and physical action on the substances being heat treated within the heat-treating chamber.

Brick kiln. GEORGE W. DENISON. U. S. 1,721,774, July 23, 1929. A drier kiln for brick and tile of the car tunnel type having in combination an air duct and air blower for supplying preheated air to the tunnel at the ware exit end thereof, a valve associated with the air-supplying duct for mixing atmospheric air with the drying air before being introduced to the tunnel, air suction means at the opposite end of the tunnel for drawing air in a saturated condition from the tunnel, a valve associated with the air-suction means for regulating the velocity of the saturated air as it traverses the ware-introductory end of the tunnel, a plurality of furnaces and longitudinally extending flues for supplying heat to the air as it traverses the tunnel, and transversely extending atmospherically sealed tunnels at each end of the drier tunnel, whereby the ends of the drier tunnel proper may be maintained open without causing atmospheric interference with the regulation of the velocity and temperature of the drying air.

Fire-door construction. LUTHER S. SWEARENGIN. U. S. 1,724,052, August 13, 1929. A fire-door construction comprising superposed metallic panels of fluted or corrugated sheet material having the flutes or corrugations of one panel extending at right angles to those of the other panel, and means binding the margins of the panels together comprising inner and outer angle bars embracing the margins between them with one leg of the outer angle bar surrounding the panels and extending continuously around the corners thereof and projecting across the outer margins thereof, and being secured to one of the legs of the inner angle bar, the other legs of the angle bars being secured exteriorly to the exposed faces of the panels, respectively.

Firing ceramic ware. ARTHUR S. WATTS. U. S. 1,724,238, August 13, 1929. In a continuous tunnel kiln for firing ceramic ware, distinct zones for the various stages of biscuiting, vitrifying, glazing, and annealing, and a temperature drop zone between each of the zones, whereby each stage of the firing treatment may be accomplished independent of the heat action of the preceding and succeeding stages.

Circular kiln. OTTO BUSCH. U. S. 1,724,392, August 13, 1929. A circular kiln divided into a plurality of kiln chambers and having a discharge flue communicating with the chambers and extending around the entire kiln, means for closing the communication between each particular chamber and the discharge flue, a centrally disposed superstructure on the kiln having a series of flues, means for setting the latter flues separately into communication with different kiln chambers through the roofs of the latter, the kiln being provided with closable apertures through which the kiln chambers can communicate through the roofs with the atmosphere, and a fan communicating with one of the flues in the superstructure for supplying gas to the latter and to the different chambers.

Brick, etc., kilns. C. ROST. Brit. 311,246, July 3, 1929. "Annular" kilns for firing brick, pottery, etc., are heated by a mixture of powdered fuel and air delivered to the kiln chamber through narrow slots in the walls and roof. The slots may flare toward the kiln chamber, and the mixture is preferably supplied at the lowest pressure at which the fuel can be conveyed.

Tunnel kilns. H. M. ROBERTSON. Brit. 311,316, July 3, 1929. In a kiln more particularly adapted for the continuous firing and glazing of ceramic goods, hot air and

combustion products are drawn through the preheating and firing zones in the same direction as the goods under treatment. The kiln comprises preheating, firing, and cooling zones with main and supplementary fireplaces, and salt glazing fireplaces in the firing zone, air-heating pipes at the sides of the cooling zone, and flues in the roof of the firing and preheating zones, by which air from the pipes can be supplied to delivery conduits spaced along the preheating zone. The products from the fireplaces and the air from the preheating zone are exhausted by a fan through headers and pipes. One side wall of each fireplace is inclined, and between these fireplaces and the exhaust headers are wall recesses which promote mixing and circulation of the gases. The fireplaces deliver into the kiln chamber through secondary combustion chambers having perforated walls on the sides facing the tunnel. The passages in the roof are formed by partition between inner and outer arches and the two innermost passages are connected to the end delivery conduits and so on in succession along the length of the preheating zone. The arch may be covered with insulating material. The side walls of the kiln are formed by inner and outer walls with an interposed filling of insulating material.

Firing china, etc. C. BAILEY AND R. T. LEWIS. Brit. 311,621, July 10, 1929. Bats or shelves for use in firing articles of china, earthenware, etc., in kilns are arranged in tiers carried by tapering props, which pass through holes in the bats and are hollowed at the base in order to fit over the corresponding lower props. The holes in the bats and the upper ends of the props are preferably of cylindrical form. An iron bedplate rests on an insulating bed and is connected to it by a screw having a conical head and nut. The recess in the base of the lowest prop fits over the conical nut.

Brick kilns. A. HABLA. Brit. 311,884, July 10, 1929. In a continuous kiln comprising two parallel permanent walls with waste gas and hot air flues, division walls, formed by the unfired goods, are arranged to leave passage ways, alternately at opposite sides of the kiln, and the brick forming these walls are set loosely so that gases can pass both through the walls and around their ends. The draft is controlled during working either by paper partitions, or by removable metal plates inserted between the two parts of a double partition wall. To prevent entrance of air at the top of the kiln each plate has a sand gutter along its upper edge, into which dip sealing caps. Connections to the hot air flue are made by removable pipes. Two or more chambers may be arranged side by side and connected for continuous working by end flues, and where more than two chambers are provided one of them may be used as a drying chamber.

Tunnel kilns. GIBBONS BROS., LTD. Brit. 312,786, July 24, 1929. In a tunnel kiln in which for at least part of the length of the kiln the tunnel atmosphere is circulated separately from the heating-gases, the circulating system includes openings in the crown of the kiln and heating chambers in the side walls communicating with the tunnel through ports near the goods platforms. In the direct-fired kiln having firing and preheating zones, respectively, the heating-gases are withdrawn from the tunnel through damper-controlled openings into side-wall chambers from which they pass through banks of tubes to the waste flue. The tunnel may be put in direct communication with the waste flue through damper-controlled passages.

Brick kilns. O. A. VERMORCKEN. Brit. 312,942, July 24, 1929. In a gas-fired brick kiln the gas is supplied to a chamber beneath the floor and passes then through radial flues to the firing ports. Air for combustion is supplied through ports and the products escape through radial sole flues arranged between the gas flues. Gas may also be supplied through a central port and the flues are formed with cleaning-extensions. The gas and air inlets, and the chimneys are damper-controlled. In a modification the gas chamber is annular and surrounds a central outlet well for the gases.

Combustion air for gas burners. C. LOEBBECKE. Ger. 469,180; *Gas Age-Rec.*, **64** [2], 60 (1929).—The quantity scale of the individual gases or of the total gas and of a

single gas in ratio to the heating value is actuated over an adding or subtracting device on the quantity indicator for the total combustion air fed through the individual pipes. F.P.H.

Electrical gas purifier. ANON. Ger. 469,652; *Gas Age-Rec.*, **64** [2], 60 (1929).—The apparatus is provided with precipitating electrodes and is characterized by possessing a device for driving the dust, which is deposited in the slit-like openings, into the interior of the box-electrodes. The electrodes are accordingly first moved slowly in the direction of the flow of gas, and then moved back quickly, so that the dust deposited in the slit-like openings falls into the box-electrode. F.P.H.

Geology

Polysynthetic twinning in dolomite. AUSTIN F. ROGERS. *Amer. Mineral.*, **14** [7], 245–50 (1929).—It is not generally known that polysynthetic twinning is fairly common in dolomite. No mention of it is made, *e.g.*, in such standard works as Dana's System of Mineralogy and Miners' Mineralogy. Some authors go as far as to say that the absence of polysynthetic twinning in thin sections distinguishes dolomite from calcite. The purpose of this article is to show that polysynthetic twinning is common in dolomite and also to show that by means of this twinning, dolomite may often be distinguished from calcite, since the twinning-law for dolomite is different from that for calcite. The wide-spread prevalence of lamellar twinning parallel to (02–21) in metamorphic dolomite rocks gives this method of twinning a petrographic as well as a mineralogic importance. The presence of twin-lamellae furnishes us a good method of distinguishing dolomite from calcite. R. has never found any of the polysynthetic twinning in the dolomite of sedimentary rocks. This fact makes it probable that the twinning is the result of pressure. F.P.H.

Base exchange in artificial autunites. J. G. FAIRCHILD. *Amer. Mineral.*, **14** [7]. 265–74 (1929). F.P.H.

Artificial gem-stone isomorphous with spinel. PAUL F. KERR. *Amer. Mineral.*, **14** [7], 259–64 (1929).—Two crystalline types of artificial gem-stones are now manufactured on a commercial scale. From the chemical standpoint these are either alumina or magnesium-aluminate. The alumina type (artificial corundum) has been manufactured in several different colors for some time. Magnesium-aluminate gem-stones, however, have only recently assumed commercial importance in the artificial gem trade. F.P.H.

Cryolith. ANON. *Emaillewaren. Ind.*, **6** [22], 177–78 (1929).—Natural cryolith is found only in Greenland in sufficient quantities. The mines are owned by Denmark. The Pennsylvania Salt Mfg. Co. of Philadelphia is the American distributor. The compositions of four synthetic cryoliths are given. T.W.G.

Selected bibliography of minerals and their identification. OLIVER BOWLES. Bur. Mines, *Information Circ.*, No. 6148, 4 pp. (1929).—The bibliography includes the simpler texts on geology, mineralogy, methods of identifying minerals, prospecting, and similar subjects. Other texts contain glossaries which define the technical terms used. A short note following the title of the book indicates the character of each book, the number of pages, and price. To supply the needs of more advanced students, quite a number of the standard texts used in schools and colleges are included in a second group. A short list of books on economic geology and mineralogy has also been added. R.A.H.

Magadi soda exports increase. ANON. *Glass Ind.*, **10** [8], 184 (1929).—Exports of soda ash made from the natural soda deposits of Lake Magadi in Kenya, Africa, increased 38% in 1928 over the preceding year (56,675 to 78,257 T.). Practically all of

this soda goes to the Far East, chiefly Japan. It competes against American soda ash in the Far East. E.J.V.

Canadian cobalt production. ANON. *Can. Chem. Met.*, **13** [8], 31 (1929).—The production of cobalt in Canada in 1928 was 956,590 lbs., valued at $1,872,320 in comparison to 880,590 lbs., worth $1,764,534 in 1927. Exports amounted in value to $1,734,461, compared to $1,678,468 in 1927. One-half the world's supply of this mineral is produced in Canada, the remainder being found in the Belgian Congo, where cobalt occurs in association with copper. E.J.V.

Texas potash. ANON. *Chemicals*, **32**, 1–2 (1929).—Mining operations in the Permian Basin of West Texas have commenced and a refinery for 2000 T. a day is being built. The first bed at the 1980-ft. level is computed to contain 23 million T. of K_2O, and the polyhalite layers below 2150 ft. to contain 54 million T. H.H.S.

BOOKS

Complete Survey on Georgia Mineral Deposits. RICHARD W. SMITH. Georgia State Geological Survey. 500 pp.—The largest deposits of sedimentary white clay in the world are located in Georgia, and the value of the state's output for a single year is approximately $1,500,000. It is stated that Georgia produces 42% of all pottery and paper clay in the U.S. and that the industry has been showing a satisfactory expansion and development for the past few years. Reviewed in *Brick Clay Rec.*, **75** [3], 151 (1929). E.J.V.

Asbestos, Its Sources, Extraction, Preparation, Manufacture, and Uses in the Engineering Industry. BECKER AND HAAG, Berlin, 1929. 88 pp., illus., bibliography. Reviewed in *Mining and Met.*, **10** [272], 18 (1929).—This illustrated volume is evidently issued as sales promotion literature by Becker and Haag, but it is in the form of an ordinary book much larger than its page numbers would indicate, as there are over 50 full-page and double-page illustrations which are not numbered. Its scope is indicated by its sub-title, and while here and there it says a good word for products of the company it is largely free from sales propaganda. It describes the deposits of the world and naturally gives most space to Canada; South Africa gets too little in proportion to Russia. A number of maps and charts are given. No price for the volume is stated. F.P.H.

Chemistry and Physics

Capillary suction of some ceramic materials. A. E. R. WESTMAN. *Jour. Amer. Ceram. Soc.*, **12** [9], 585–95 (1929).—The forces which act when clay is mixed with water and when water is removed from wet clay by evaporation have received little study. For this reason, very little definite information regarding the internal mechanism of the drying of clayware is available. In this paper, W. reviews the experiments and theories of Pukall, Terzaghi, Dixon, etc., lists some of the forces which may act when ware is drying and defines an important force which he calls "capillary suction." A simple experiment is described by means of which this force can be readily demonstrated. The development and final form of an apparatus for measuring the capillary suction of ceramic materials is described and data obtained from measurements on a ball clay, a kaolin, flint, feldspar, and mixtures of these substances are reported. Capillary suction decreases rapidly with increase in the flint and feldspar of a ceramic body. By utilizing the capillary suction produced by evaporation of water from a clay surface, water at atmospheric pressure has been made to enter a steel bomb in which the gas pressure was maintained at 200 lbs. per square inch.

Use of ortho-hydroxyquinoline in industrial ceramic laboratories. W. MIEHR AND P. KOCH. *Tonind.-Ztg.*, **52** [103], 2057–58; [104], 2076–77 (1928).—The determination of alumina in silicates with the aid of ortho-hydroxyquinoline is described and

the possible accuracy obtainable with this method is discussed and compared with other methods. A rapid method for the analysis of silicates is outlined. F.P.H.

Determination of free aluminum oxide in silicate mixtures and application of method to kaolins and clays. L. SCHMELOW. *Tonind.-Ztg.*, **52** [90], 1808 (1928).—An alizarin red SX dye in a solution in alcohol is saturated with boric acid and used as an indicator in testing for the presence of aluminum oxide. The test is very sensitive. Diaspore does not respond to this test. F.P.H.

Use of 8-hydroxyquinoline in separations of aluminum. G. E. F. LUNDELL AND H. B. KNOWLES. Bur. Stand., *Jour. Research* [Rept. No. 86], **3** [1], 91–96 (1929).—The data presented show that precipitations with 8-hydroxyquinoline serve to separate aluminum from phosphorus, arsenic, fluorine, and boron if made in ammoniacal solutions, from tantalum, columbium, titanium, and molybdenum if made in ammoniacal solutions containing hydrogen peroxide, and from uranium if made in ammonium carbonate solutions. R.A.H.

Determination of ferrous iron in silicate rocks. BYRON A. SOULE. *Jour. Amer. Chem. Soc.*, **50** [6], 1691–94 (1928).—S. points out three objections to the usual method of determining ferrous iron in rocks: (1) the need for a large expensive platinum crucible, (2) the impossibility of seeing when decomposition is complete, (3) the necessity for transferring the readily oxidized ferrous solution to another dish for titration. A mixture of hydrofluoric acid and sulphuric acid can be boiled in Pyrex glassware for some time without perforating the container. Quartz ware is even more resistant than Pyrex. Comparative tests have demonstrated that quartz is more satisfactory for the permanganate titration of ferrous iron in that it does not appreciably absorb light at the violet end of the spectrum. S. found that a Pyrex flask would stand about twenty determinations before giving way. He concludes that platinum ware is not essential for the determination of ferrous iron in rocks. A correction factor for Pyrex glass was determined. R.G.M.

Occurrence of some rare elements in clays. A. FIOLETOFF. *Keram. Rundschau*, **35**, 270–72, 288–89 (1927).—The results of analyses of Russian clays for TiO_2, VO_5, and ZrO_2 are given. All of these oxides occur in significant amounts in clays and should be determined more frequently. Secondary clays usually contain more TiO_2 than primary clays. The determination of these oxides may assist in clearing up stratigraphical problems where non-fossiliferous clay beds are members of the stratigraphical series. H.I.

Volumetric determination of ferrous iron by means of potassium iodate. G. B. HEISIG. *Jour. Amer. Chem. Soc.*, **50** [6], 1687–91 (1928).— H. found this method very practical. Potassium iodate solution can be prepared by dissolving the calculated amount of pure dry reagent in water. The solution requires no further standardization and is permanent. The ferrous iron is oxidized quantitatively by iodine chloride and the iodine liberated can be titrated with potassium iodate after adding 50% by volume of hydrochloric acid. The presence of many organic compounds does not affect the titration. R.G.M.

Preparation of boric acid anhydrite and its efficiency as a drying agent. J. H. WALTON AND C. K. ROSENBAUM. *Jour. Amer. Chem. Soc.*, **50** [6], 1648–50 (1929).—Samples of boric acid crystals were heated to temperatures ranging from 800 to 1000°C, and ball milled for 3 days, producing 90% 160-mesh powder. The boric oxide content was found to range from 76.1% in the sample heated to 800°C to 62.3% in the sample heated to 1000°C. The drying efficiencies of the samples were determined by passing air saturated with moisture through a U-tube filled with the boric oxide. The results indicated that boric acid anhydride is more efficient as a drying agent than sulphuric acid and calcium chloride but is somewhat inferior to phosphorus pentoxide and magnesium perchlorate. R.G.M.

Rational analysis of clays. A. F. FIOLETOFF. *Keram. Rundschau*, **35**, 187–89 (1927).—The method used consists in igniting the clay at about 550°C to constant weight, treating the ignited sample (about 0.75 g.) with 50 ml. of 10% HCl over a steam bath in a closed vessel for 10 hrs., filtering, washing, and treating the residue with 50 ml. of 10% Na_2CO_3 solution in a covered platinum vessel over a steam bath for $^1/_2$ hr. The ignition loss is considered as combined H_2O and is calculated to kaolin. K_2O taken into solution in HCl is calculated to muscovite mica. The rest of the K_2O (known from a complete chemical analysis of the clay) is calculated to potash feldspar. The difference between SiO_2 found by analysis and SiO_2 required to satisfy H_2O for kaolin, K_2O for muscovite mica and K_2O for feldspar is considered as quartz. Results of control treatments of quartz, muscovite mica, and feldspar with HCl and Na_2CO_3 solutions are given. H.I.

Apparatus for continuous gas analysis. E. C. WHITE. *Jour. Amer. Chem. Soc.*, **50** [8], 2148–54 (1928).—W. describes several set-ups for an apparatus designed to afford a continuous determination of moderate concentrations of a given constituent in a flowing gas mixture and to register the concentration automatically by electrical means. The apparatus has been used successfully for the determination of small concentrations of carbon monoxide in the presence of hydrogen, methane, and other gases. An actual adaptation of the equipment used for the determination of this gas is described completely. Possibilities for the extended use of the apparatus are indicated. R.G.M.

Classification of mullite. D. BELJANKIN. *Ber. deut. keram. Ges.*, **10** [4], 232–33 (1929).—W. Eitel has stated that mullite is not a mineral but a mechanically dispersed mixture of the mineral sillimanite with very fine particles of alumina in it. B. prepared and isolated crystals obtained by fusing a kaolin with alumina and found their composition to be SiO_2 28.29%, Al_2O_3 71.02%, which is very close to the mullite as described by Bowen and Greig. From the chemical and optical data one might give several explanations of the situation, namely: (1) mullite is a homogeneous solid solution of Al_2O_3 in sillimanite, (2) sillimanite is a solid solution of SiO_2 in the crystal phase, mullite, and (3) both minerals, mullite and sillimanite, are true minerals, and each is an independent crystalline phase. F.P.H.

Investigations on firing refractory clays. ANON. *Brit. Clayworker*, **38** [447], 138 (1929).—A review of the recent extensive study by Dr. Miehr of Stettin on refractory clays, showing that the essential product in fired clay is the crystalline mineral, mullite, and why such great variations occur in the firing of different clays. The optimum temperature for the formation of mullite varied from 1500 to 1600°C and the extent to which it is formed depends on the size of the particles of true clay and on the proportion and nature of the fluxes present. In clays which contain free silica, crystals of cristobalite are formed at the same time as those of mullite, and some fused silica, or a glassy mass rich in silica usually occupies the spaces between the crystals. Although the conversion of a large proportion of clay into mullite does not occur below 1500 to 1600°C, the formation begins at about 1000°C and is well advanced in some clays at 1400°C, though the crystals are very small. This study shows that the amount of mullite formed does not depend on the total alumina in a clay, but only on that in the form of true clay or clay substance. It was found impossible to use the changes in specific gravity of the material during firing to determine the proportion of mullite formed. R.A.H.

New investigations on the dehydration of kaolin and its bearing upon the mullite question. E. KLEVER. Vort-Ber. *Das Glas*, **22**, 257 (1928); *Tonind.-Ztg.*, **53** [6], 119 (1929). F.P.H.

Phosphorescence of fused quartz. A. C. BAILEY AND J. W. WOODROW. *Phil. Mag.* [Supp. 7], **6** [40], 1104–1107 (1928).—Experiments are described which show that samples of fused quartz possess the properties of a phosphorescent body, *i.e.*, if they are

excited by ultra-violet light, they will emit a visible phosphorescent light of considerable strength upon the application of heat, and they can be completely deactivated by bringing to a red heat in a flame. This phosphorescent activity of fused quartz is not uniform but there is a wide variation between samples and even within the area of a single small piece. Natural quartz crystals do not possess this property of emitting a phosphorescent radiation, but they can be brought into this condition by heating slowly in an electric furnace to a temperature of 1600°C. Pyrex glass, calcite, and fluorite exhibit a prominent phosphorescent activity, but gypsum does not. J.T.L.

Graphical representation of 4-component systems. H. PHILLIPSBORN. *Tonind.-Ztg.*, **53** [3], 45–48 (1929). F.P.H.

Clays. XIII. Flocculative action of hydrophilic sols on suspensions of clays and its practical uses. T. OKAZAWA AND T. SANO. *Bull. Inst. Phys. Chem. Res.* [Tokyo], **8,** 356–68 (1929).—Suspensions of clay are readily flocculated by the addition of small quantities of hydrophilic colloids. The flocculation values for casein, albumin, gum arabic, and starch are small, gelatin has a high value, but the most effective agent is a solution of "Konnyaku-ko" (a powder obtained from the tuberous root of the devil's tongue), which precipitates clay suspensions when present at a concentration of only 2 parts per million. An acid suspension of clay is more susceptible to flocculation than an alkaline suspension. Suspensions of charcoal in water are difficult to flocculate by hydrophilic colloids, but are readily flocculated thereby after addition of a small amount of clay. Clay particles in nonaqueous media also are flocculated by hydrophilic colloids. The precipitated particles are much coarser than those flocculated by electrolytes, and the method is therefore applicable to the acceleration of filtration in industrial processes. (*B.C.A.*)

Studies of hydrogen-ion concentration measurements. I. Methods of measurements. C. E. DAVIS AND G. M. DAVIDSON. *Jour. Amer. Chem. Soc.*, **50** [8], 2053–65 (1928).—The purpose was to test the effectiveness and technique required in electrometrically determining hydrogen-ion concentration of a solution by means of the condenser arrangement. Measurements of electromotive force by the condenser method were compared directly with those obtained by the standard potentiometer method. The authors conclude that the important errors in this method are due to the accumulation of errors on the plates of the condenser, the throw of the galvanometer, humidity, and the formula used in the calculation of the unknown electromotive force. The important errors are calculated and graphs are shown which illustrate the significance of such errors in the titration of sulphuric acid and orthophosphoric acid. The accumulative error may reach a value approximating ± 3.0 to 4.0 millivolts. Results indicate that the condenser system cannot be used for very precise work. R.G.M.

Mechanical properties of the clay-water system. OTTO BARTSCH. *Ber. deut. keram. Ges.*, **10** [3], 146–84 (1929).—It is a well-known fact from the work of Bingham, Ostwald, and others that as the clay concentration in the clay-water system is increased the mechanical properties of the system approach those of a solid body. An apparatus for determining the resistance to deformation offered by a clay slip is described and the method of performing the test is given in detail. The effect of varying the water content of slips of various clays on the deformation resistance of the slips is investigated. The action of various electrolytes on the deformation resistance of slips containing various clays is also investigated. The exact relation between this "deformation resistance" as determined by Bartsch and the "yield value" as determined by Bingham is not known. The requirements of a good casting slip for large bodies of complicated form are discussed in relation to the "deformation resistance" of the slip. With increasing clay concentration an increase in the deformation resistance of the slip results. The latter increase follows a course which is characteristic of the clay or clays present in the clay-water

system. This deformation resistance of a slip is a characteristic property of that slip and is supposed to define the state of the clay-water system. Bartsch's method is applicable to systems with much higher clay concentrations than Binghams' method.

F.P.H.

Clay in the light of colloidal science. GUSTAV KEPPELER. *Ber. deut. keram. Ges.*, **10** [3], 133–46 (1929).—The following subjects are discussed: (1) distinctions between colloids and crystalloids, (2) principle of the ultramicroscope, (3) Brownian movement in clay colloids, (4) the electrical charge on colloidal particles and the effect of this charge in producing deflocculation, (5) the adsorption of ions by colloidal clay particles, (6) the effect of humates in producing deflocculation, (7) plasticity of clay and the rôle of colloids in producing this property. F.P.H.

Determination of viscosity in absolute units. ANON. *Mech. World*, **86** [2219], 28 (1929).—A revised issue of B. S. Specification No. 188, 1929 (British Standard Method for the Determination of Viscosity in Absolute Units), has just been published by the British Engineering Standards Assn. The first edition of this specification appeared in 1923, and the present revision was undertaken in the light of criticisms and suggestions which have since been received. The opportunity was taken of recasting the entire specification, and also of introducing data likely to be of service to users, which have been incorporated in several new appendices. The revised specification should prove of considerably increased value to all laboratories engaged in work on viscosity. E.P.R.

Molecular theory of friction. G. A. TOMLINSON. *Phil. Mag.* [Supp. 7], **7** [46], 905–39 (1929).—On the basis of the theory proposed to explain friction a certain number of molecules of one body in the case of a relative sliding motion will approach those of the other body sufficiently closely to suffer repulsion. As any material surface will have a coarse structure compared with the range of repulsion force, many other molecules of the one body may experience attraction to the molecules of the other body without entering the repulsion field at all. When the two bodies are moving relative to one another, there is a continuous change taking place in the pairs of molecules bearing the load and the theory assumes that as a pair of molecules comes in each other's repulsion field a loss of energy is incurred which is manifest as friction. On the basis of the theory a relationship between the coefficient of rolling friction and of sliding friction is developed. Experiments made confirm the theory. A relationship between the elastic properties of the body and coefficient of friction is developed. Measurements of the coefficient of friction between a number of materials are made and given in tables. Some unusual kinds of friction which were encountered in the process of the experimental work were discussed. The validity of the theory depends on the assumption that the repulsion forces between molecules has a much greater rate of change and a smaller range of action than the attraction forces. It is shown how the same hypothesis is consistent with the ordinary phenomena of elasticity. J.T.L.

Yellow color of lead glazes. H. MÖHL AND H. LEHMANN. *Sprechsaal*, **62** [26], 463–65 (1929).—Yellow color, especially under oxidizing influences, is not due to Pb_3O_4 but due to the excess of PbO in the melt. The PbO can be combined with alkali to destroy the yellow. The doubtful investigation of the system PbO–SiO_2 is emphasized.

T.W.G.

Preparing thin specimens for microscopic examination. R. A. RAGATZ. *Mining and Met.*, **10** [272], 372–77 (1929).—Ordinarily, the preparation of metallographic specimens involves the following operations: (1) cutting the small specimens to be examined out of the larger mass of metal, (2) cleaning and electroplating, (3) mounting to furnish support during the grinding and polishing operations, (4) grinding and polishing to produce a scratch-free surface, and (5) etching and drying. These must be carried out in such a manner that the structure is a true and well-defined representation of the

structure that the larger mass of metal possesses at the place where the small specimen was removed. It is important that the deformation involved in cutting out the specimen be as slight as possible. F.P.H.

Specific heats at low temperatures of manganous oxide, manganous-manganic oxide, and manganese dioxide. R. W. MILLAR. *Jour. Amer. Chem. Soc.*, **50** [7], 1875–83 (1928).—M. includes tables and charts showing the specific heat capacities from 70 to 300°K and also the free energies of these substances at 298°K. R.G.M.

Measurement of the coefficient of thermal conductivity of insulating materials. I. L. HEYBERGER. *Rev. mat. constr. trav. pub.*, No. 228, pp. 199–201B (1928).—The coefficient of thermal conductivity is defined and the systems of units are discussed. Methods of measuring the coefficient are explained and a table of coefficients of different materials (Wologdine's results) is given. II. *Ibid.*, No. 229, pp. 229–31B (1928).—The discussion of various methods of measuring the coefficient is continued. A.J.M.

Differential apparatus for measuring the volume of soils. J. PADEREWSKI. *Proc. Internat. Soc. Soil Sci.*, **4**, 56–57 (1929).—Apparatus is described for the measurement of soil volumes by determining differences in air pressure resulting from the introduction of the soil sample into a closed space. (*B.C.A.*)

BOOKS

Gases and Liquids. J. S. HALDANE. Oliver and Boyd, Edinburgh, 1928. 334 + xv pp. Reviewed in *Mech. World*, **86** [2218], 18 (1929).—The book is mainly concerned with the molecular physics side of the subjects; the chapters devoted to liquid and gaseous states, and internal pressures and saturated vapors of liquids are worthy of the close attention of all those interested in these aspects of physical science. In addition to the above-mentioned sections there are two chapters on a critical examination of the accepted principles underlying the conception of the Carnot cycle for heat engines. In short, H. maintains that the maximum possible efficiency of such an engine is $\frac{T_1 - T_2}{2\,T_1}$ and not the usually accepted one, $\frac{T_1 - T_2}{T_1}$. The method of arriving at this result is not a technical process, but rather a piece of philosophical analysis. Other chapters deal with the dynamical theory of gases and heat, gaseous diffusion and osmosis, osmosis in liquids, and depression of freezing points and vapor pressures in solution. To the chemical engineer all these are subjects of first importance. E.P.R.

Physical Chemistry of Silicates. WILHELM EITEL. 552 pp., 459 illus., price 63 Rm. Published by Leopold Voss, Leipzig. Reviewed in *Keramos*, **8** [12], T9, 453–54 (1929), by Dr. Félix Singer. F.P.H.

PATENTS

Production of white lead. FRANK T. BAILEY AND WILSON AUSTIN. U. S. 1,723,001, August 6, 1929. The method of making corroded white lead which comprises passing powdered anhydrous lead oxide through a corroding atmosphere of aqueous vapors, acetic acid, and carbon dioxide.

Manufacturing black ash. ZOLTAN DE HORVATH. U. S. 1,723,138, August 6, 1929. In the method of manufacturing black ash from barytes in which a mixture of barytes and carbonaceous material is passed through and heated in a rotary kiln, the improvement which consists in adding to the mixture carbonate of calcium in quantity sufficient to combine with a substantial quantity of the silica present in the barytes.

Manufacture of chromium compounds. PAUL WEISE. U. S. 1,723,536, August 6, 1929. In the manufacture of chromium compounds by heating an excess of chrome ore with an alkaline agent and leaching the chromium compounds out of the reaction mass, the step which comprises preparing the residue after leaching for reuse in the process by treatment with an excess of acid.

Production of green hydrated chromium oxide. KURT H. MEYER AND HANS KRZIKALLA. U. S. 1,723,556, August 6, 1929. A process for the production of green hydrated chromium oxide which consists in heating a compound of hexavalent chromium in the presence of water at a pressure above atmospheric pressure but below 150 atmospheres with a reducing agent, other than sulphurous acid.

Art of refining borax. CHARLES F. RITCHIE AND WILLIAM A. GALE. U. S. 1,724,420, August 13, 1929. The improved method of crystallizing essentially pure boric acid compounds from liquors containing phosphates and boric acid compounds in such proportions that boric acid compounds crystallized therefrom in substantial amounts would contain phosphates as impurities, which comprises treating such liquors with a reagent which reduces the alkalinity (p_H value) of the solution, thereby increasing the solubility of the phosphates and crystallizing out the boric acid compound from the resulting solution substantially free from phosphates.

Sodium perborate. G. SCHOENBERG. Brit. 312,664, July 24, 1929. Anhydrous sodium perborate is prepared by first heating the crystalline salt at 40 to 100°C with agitation and if desired *in vacuo* until about three molecules of water of crystallization have been driven off, and then completing the dehydration *in vacuo* at about 100 to 120°C, if desired with agitation and in a current of dry inert gas such as air. In the second step the vapor tension must not substantially exceed 40 mms. of mercury, and is preferably maintained below 30 mms., and the temperature where the greatest concentration of water vapor occurs, especially where it leaves the apparatus, should be lower than elsewhere. The process may be effected in a rotatable aluminium drum. The product from the first step of the process may be shaped into tablets, etc., and dehydration may then be completed in the containers such as glass vessels employed for storage or transport of the anhydrous salt.

Barium silicates. S. WITTOUCK. Brit. 312,975, July 31, 1929. In the production of barium silicates, for instance di- or tri-barium silicate by calcination of silica or monobarium silicate with barium sulphate, for instance at 1500°C and in the presence or absence of carbon or gases such as carbon monoxide, fusion is avoided by addition of a diluent infusible at the calcination temperature. Preferably the diluent consists of a quantity of the silicate which it is desired to obtain, and preferably so much is used that fusion of the whole mass undergoing calcination is avoided. A portion of the product from one operation may be used as diluent in a succeeding operation whereby the process may be made continuous; in such case there is preferably removed from the process at each operation as much of the product as corresponds to the reacting components. Sulphur, sulphuric acid, or carbon dioxide evolved in the process may be recovered.

Base-exchanging substances. REYMERSHOLMS GAMLA INDUSTRIE AKTIEBOLAG. Brit. 313,522, August 8, 1929. The residue of "waste clay" obtained when natural silicates such as kaolin, bauxite, or refractory clays are decomposed with acid, etc., and consisting essentially of silicic acid and iron and aluminium oxides, is boiled under pressure with oxides, hydroxides, or carbonates of the alkali or alkaline earth metals or mixtures thereof to obtain directly hydrated base-exchanging substances. Hard products are obtained when lime is used as one of the alkaline agents. Prior to use, the product may be washed with a solution of common salt or other alkali salt until free from lime. The fusion of "waste clay" with an alkali or alkaline earth hydroxide, etc., followed by hydration of the product is described but not claimed.

General

Some operating results on small heating plant stokers. J. F. BARKLEY. Bur. Mines, *Rept. of Invest.*, Serial No. 2946 (1929).—Tabulations and graphs are given which show the results of a series of operating tests on two types of small stokers. One

was an inclined, natural-draft, moving grate, overfeed "hand stoker," fired and manipulated by hand; the other was a horizontal, forced-draft, stationary-grate, underfeed, mechanical unit-stoker operated by an electric motor. The boiler was a horizontal return tubular of 150 bl. H.P. each. The per cent efficiency of the boiler using the mechanical stoker is the greater. R.A.H.

Tests of bituminous coking coal in a large low-pressure heating boiler. P. NICHOLLS, C. E. AUGUSTINE, AND B. A. LANDRY. Bur. Mines, *Rept. of Invest.*, Serial No. 2943 (1929).—When bituminous coal is burned in a hand-fired updraft boiler used for heating purposes it has a decided tendency to produce smoke. To supplement tests reported in Bur. Mines, *Tech. Paper*, No. 303, additional studies have been made to determine how changes made by manufacturers in furnace design for use with bituminous coal affected the production of smoke and efficiency of the boiler. The test results are reported in this report. R.A.H.

Tentative method for making resistivity measurement of drill cores and hand specimens of rocks and ores. M. W. PULLEN. Bur. Mines, *Information Circ.*, No. 6141, 11 pp. (1929).—This is the first of a series of papers dealing with the measurement of geophysical constants to aid in prospecting in the U.S. The present paper presents a tentative method and the results of tests of drill cores from the Mineville magnetite district and of hand specimens of serpentine and chromite. The conclusions listed are as follows: (1) Surface leakages of current must be reduced for reliable resistivity measurements. (2) Resistivity measurement is associated with electrical polarization, and the factor of time therefore enters as an element in its determination. (3) The rate of polarization differs in various rocks. (4) There is a variation of resistivity as a function of applied voltage and frequency. (5) Because of low values of measured current, d. c. instruments must be used in a. c. circuits when measuring a. c. resistivity. (6) There is a difference between a. c. and d. c. resistivity. (7) A definite method is proposed for preparing drill cores and hand specimens for resistivity measurements. (8) Rock specimens of the same classification from different horizons of a drill core may show a wide variation of resistivity due to the latitude in the rock classification. (9) Water content may greatly alter the resistivity of materials. (10) Resistivity of a conducting ore body may be high if the particles of ore are disseminated. R.A.H.

Working costs of artificial brick drying plant. HANS DENDL. *Tonind.-Ztg.*, **53** [14], 268–69 (1929).—The cost of operating two driers when hollow tile and roofing tile are being dried is discussed. A large drier operates at a cost of 6 M per thousand pieces while a slightly smaller drier costs 7 M per thousand pieces. F.P.H.

Slow drying or rapid drying. G. ZEHNER. *Rev. mat. constr. trav. pub.*, No. 223, pp. 87–88B (1928).—The rate of drying is entirely dependent on the product being dried and careful study should be made to determine the shortest possible time of safe drying. A.J.M.

New artificial drier. A. HIELSCHER. *Rev. mat. constr. trav. pub.*, No. 229, pp. 224–27B (1928). A.J.M.

Artificial drying. ANON. *Rev. mat. constr. trav. pub.*, No. 227, pp. 172–73B (1928).—A review is given. A.J.M.

Drying in the ceramic industry. HENRY L. GALSON. *Ceram. Ind.*, **13** [2], 147–49 (1929).—The evaporation of water from any mass is largely dependent on the physical characteristics of the matter to be dried, as well as a difference in vapor pressure existing between the ware and the surrounding air. Of the above factors, the basic one is of course the material to be dried, and its consistency, structure, and shape determine in most cases the maximum safe drying speed and also affect the other variables entering into the most economical method of drying. To obtain a high quality product, ceramic ware has to be dried from the inside out, and it is therefore evident that evaporation

cannot take place faster than the minute particles of water can penetrate through the capillary pores from the interior of the piece to the outside if case hardening and subsequent cracking is to be prevented. The safe drying speed, therefore, depends on the relative rate of surface evaporation and replacement. F.P.H.

Increasing porosity of ceramic products. ANON. *Rev. mat. constr. trav. pub.*, No. 235, p. 91B (1929). A.J.M.

Cleaning compounds and methods. ANON. *Brass World*, **25** [2], 34 (1929).—A large variety of cleaning compounds for metals and other products are manufactured by E. F. Houghton and Co., Philadelphia, Pa., which has just issued a 34-p. booklet on the subject. The book also treats methods of cleaning metal products in various kinds of plants such as automobile factories, oil, enameling, plating and finishing works, etc. General plant cleaning operations are dealt with. The book is divided into chapters, beginning with a general introduction on the subject of metal cleaning, giving general directions. E.P.R.

Maintenance painting. ANON. *Brick Clay Rec.*, **75** [3], 152–55 (1929).—One of the most general measures of prevention against corrosion is the application of special paints to the surface of the metals. Each surface makes special requirements of paint. The properties of various different types of paints are discussed in detail. E.J.V.

Economical packing of porcelain and glass. A. PRZYZODE. *Keram. Rundschau*, **35**, 163–64 (1927).—Various methods of packing glass and porcelain in wooden and corrugated paper containers are described. H.I.

Imported clay products industry. BUREAU OF STATISTICS. *Can. Chem. Met.*, **13** [8], 37 (1929).—A new record for the production of imported clay products in Canada is reported for 1928, when the output from this industry reached a value of $2,458,801, an 18% increase over the 1927 figure. The total was made up of the following items: fire brick, stove linings, and similar refractories, $313,637; porcelain insulators, $1,321,556; pottery, $38,144; all other products (including ceramic floor tile, sewer pipe, sanitary ware, etc.), $785,464. These figures cover the operations of 14 plants, 9 in Ontario and 5 in Quebec. E.J.V.

Increased duty for perfume bottles urged. ANON. *Amer. Glass Rev.*, **48** [43], 16–18 (1929).—Adequate tariff protection for the perfume bottle industry is demanded by the Glass Bottle Blowers' Assn. E.P.R.

German progress in pulverized-coal firing. JAMES E. WALLIS, JR. *Commerce Repts.*, **31**, 357 (1929).—Statistics on pulverized-coal firing in Germany showed that on April 1, 1928, there were 914 pulverized-coal firing installations, compared with 763 in 1927. These 914 installations were divided among 272 plants and included 545 industrial furnaces and 369 steam boilers. Of the 4,800,000 T. of pulverized fuel consumed in 1928, 930,000 T. represented lignite and 3,870,000 T. bituminous coal and anthracite. E.J.V.

Present condition of plant control in German refractory industry. H. KNUTH. *Tonind.-Ztg.*, **53** [14], 270–71; [16], 316–17; [17], 330–31 (1929).—This was abstracted from *Ber. deut. keram. Ges.* (see *Ceram. Abs.*, **8** [6], 418 (1929)). F.P.H.

Leading ceramists; Nicolans B. Jungeblutt. ANON. *Keramos*, **8** [12], T8, 445–50 (1929).—A biography of Nicolans B. Jungeblutt, Director General of Deutsche Ton und Steinzeug-Werke (DTS) is given. The history and organization of the above-mentioned company are given. F.P.H.

100th anniversary of the birth of Jacob Buhrer. ANON. *Rev. mat. constr. trav. pub.*, No. 222, p. 69B (1928). A.J.M.

Education for enamel technologists. HOMER F. STALEY. *Bull. Amer. Ceram. Soc.*, **8** [8], 255–60 (1929).—The Report of the Committee on Education of the Enamel Division as presented at the February Meeting. Comments of the heads of the various

departments of ceramics are summarized as follows, regarding the report for the previous year: (1) the present curricula of the various ceramic schools are fundamental in nature. Therefore, with or without the addition of a small amount of work in enamel working, they are or should be satisfactory for the training of enamel technologists; (2) the enameling industries are not sufficiently large to justify a special course of instruction; (3) possibly men for the enameling industries should receive their training in schools other than ceramic schools. Each of these proposals is discussed briefly, each point in the comments being answered with facts which cannot be denied. E.J.V.

Science and labor. A. D. LITTLE. *Jour. Soc. Chem. Ind.*, 48T, 161–67 (1929).—The presidential address to the Society of Chemical Industry at the annual general meeting, Manchester, July 9–12 (1929). "The only remedy for unemployment is research." H.H.S.

Mineral wool. J. R. THOENEN. Bur. Mines, *Information Circ.*, No. 6142, 13 pp. (1929).—Mineral wool is composed of calcium silicate or glass-like materials similar in appearance to wool or cotton. It is used mainly for insulating purposes. Mineral wool is of two classes: rock wool prepared from a natural siliceous limestone (calcareous shale) or from an artificial mixture of silica and limestone. Slag wool is made from iron blast-furnace slags with or without the addition of limestone. The names of companies manufacturing mineral wool are listed in the report together with a discussion on mining and manufacturing practices of the various manufacturers. A discussion of the technical phases is also included. R.A.H.

American Society for Testing Materials. ANON. *Cement, Mill & Quarry*, **34**, [8], 17–20 (1929).—Increasing activity in materials and testing methods was emphasized at the recent meeting in Atlantic City. E.P.R.

Congress of Technical Ceramics. ANON. *Rev. mat. constr. trav. pub.*, No. 225, pp. 121–26B (1928).—Abstracts are given for the papers presented before the Congress which was held in Paris in May and June, 1928. A.J.M.

British Industries Fair. ANON. *Chem. News*, **139**, 26 (1929).—The British Industries Fair will be held at Olympia, Hammersmith, England, Feb., 1930. H.H.S.

Empire Mining and Metallurgical Congress. ANON. *Chem. News*, **139**, 28 (1929).—The third triennial Congress will take place next year from March 24 to May 9, 1930. Information may be obtained from the Secretary, P. O. Box 4606, Johannesburg. The two main tours will be to northern and to eastern Rhodesia, both connecting at Buluwayo on the return journey to the Union of S. Africa. H.H.S.

National Council of the Pottery Industry. ANON. *Pottery Gaz.*, **54** [626], 1259–60 (1929).—A report of the meeting held at Stoke-on-Trent, on July 17, when subjects discussed included polishing, dust from returned packages, cleaning throwers' cones, dry-ware cleaning, welfare buildings and relief from rates and taxes, standardization of shops and decoration, compulsory provision of satistics, the Josiah Wedgwood bicentenary celebrations, pottery scholarship, and unemployment statistics. E.J.V.

Society of Glass Technology. ANON. *Pottery Gaz.*, **54** [626], 1253–57 (1929).—A report of the meeting held at Sheffield at which the paper "Boric Oxide in Glass Manufacture" was presented by W. E. S. Turner, Violet Dimbleby, M. Parkin, and F. Winks. E.J.V.

Polish National Exhibition. ANON. *Chem. News*, **139**, 28 (1929).—Held at Poznan (Posen) to mark the 10th Anniversary of Polish independence, and to show the ample mineral resources of the country. H.H.S.

Ceramic industry in Poland. (Industrial note.) ANON. *Rev. mat. constr. trav. pub.*, No. 226, p. 167B (1928). A.J.M.

Italian market for ceramic raw materials. ANON. *Rev. mat. constr. trav. pub.*, No. 231, pp. 284–86B (1928).—Italy is very poor in ceramic raw materials, especially fine

clays and kaolins. These are imported from France, England, Germany, and Czechoslovakia. A.J.M.

Ceramic industry in the Netherlands. ANON. *Rev. mat. constr. trav. pub.*, No. 234, pp. 67–68B (1929). A.J.M.

Harbison-Walker Securities Co. ANON. *Amer. Glass Rev.*, **48** [43], 14 (1929).—Organized by the H.-W. R. Co., chartered in Delaware, this company has authorized capital of 1,000,000 shares, par value $100.00. E.P.R.

As the Britons saw us. A. H. STEPHENSON. *Brick Clay Rec.*, **75** [3], 150–51 (1929).—A reprint of a letter giving in detail some of the writer's impressions of America and production methods in American clay plants gained during the English Ceramic Society visit. E.J.V.

BOOKS

Handbook of Corporate Management and Procedure. EARL E. SALIERS. McGraw-Hill Book Co., N. Y., 1929. 1237 pp. Price $7.50. Reviewed in *Mining and Met.*, **10** [272], 20 (1929).—The more common problems that arise in the everyday affairs of corporations, such as the conduct of meetings of stockholders and directors, the handling of stock issues, the payment of dividends, the financing of working capital, the issuance of bonds, the transfer of capital stock, and the operation of voting trusts are discussed. The book presents data constantly wanted by those in charge of the legal, financial, and managerial activities of corporations. F.P.H.

Steam, Air, and Gas Power. W. H. SEVERUS AND H. E. DEGLER. Wiley and Sons, London, 1929. 425 pp. Reviewed in *Mech. World*, **86** [2218], 18–19 (1929).—With a chapter on the properties of steam, and on calorimetry, some consideration is given to the use of many types of fuels, *e.g.*, pulverized coal, wood, oil, and gas. The fundamentals of combustion and fuel analysis are illustrated and described before a description of boilers is undertaken. These latter parts include a good description of steam boilers and their auxiliaries, feed-water heating and treatment, turbines, steam engines, condensers, and pumps, as well as the general subject of steam-engine economy. The last part of this volume contains chapters on air compressors and their equipment, gas and oil engines in theory and practice. E.P.R.

Industrial Standardization. Edited by ROBERT A. BRADY. National Industrial Conference Board, New York, 1929. Price $3.50. Prepared under the supervision of the Conference Board's Economic Council. H.H.S.

CORRECTION

Ceramic Abstracts for August, 1929, page 604, the abstract entitled "Control of clay slips by the use of electrolyte," line 12, should be corrected to read: "With 0.125% sodium silicate and 0.125% sodium carbonate as electrolyte and no colloid, etc.," instead of $12^1/_2\%$, as it appears.

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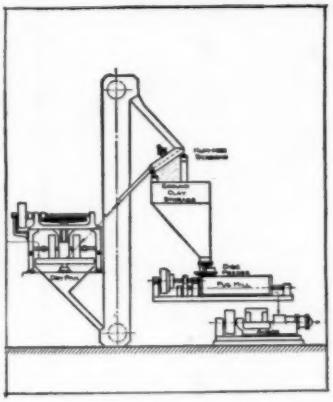

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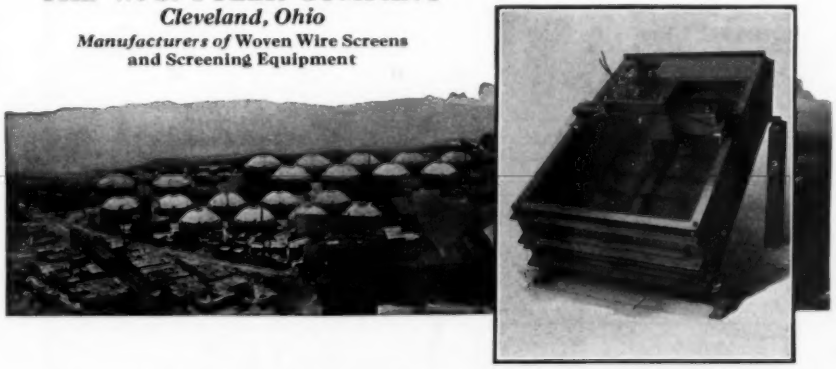

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A Monthly Publication Devoted to Proceedings of the Society, Discussions of Plant Problems, Discussions of Technical, Scientific, and Art Questions and Promotion of Coöperative Research

Edited by the Secretary of the Society Assisted by Officers of the Industrial Divisions

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EDITORIAL

RELATION OF STATE UNIVERSITY EXPERIMENT STATIONS TO NATIONAL ORGANIZATIONS IN PRODUCT RESEARCH[1]

BY MILO S. KETCHUM[2]

Introduction

Ancients Individually Versed in Industrial Arts

Last summer, when in London, I visited, among many other interesting places, the British Museum. The industrial exhibits in this Museum indicate that the ancients were well versed in many of the industrial arts. The ceramic industries were especially well represented. Many of the ancient artisans were especially skillful, but due to the fact that the knowledge of the art was in a few hands, this knowledge was lost with the passing of the individuals possessing the information.

[1] Presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Chicago, Ill., February, 1929. (General Session.)

[2] Dean of the College of Engineering and Director of the Engineering Experiment Station, University of Illinois.

Arts and Crafts by Industrial Firms

The development of industrial nations has been largely due to a revival of the arts and crafts and the application of science and invention. In the beginning, most of the research was carried on by the individual industries, and the results were used by the industries for private gain. As the industries developed, it was found profitable to carry on research investigations through the coöperation of the members of a group of industries. These investigations have been carried on either in public or private laboratories.

Collective Research

Research investigations may be of several kinds. Each manufacturer has production problems which are of special interest to him alone. These problems he can best solve in his own plant. There are other problems that are peculiar to the industry, including the development of equipment and standards of quality and workmanship. These investigations can best be carried on through coöperation. In the United States, engineering research investigations are carried on in laboratories of the industries, in private laboratories, in laboratories of the federal government, such as the Bureau of Standards, in state laboratories, in the laboratories of state universities, and in privately endowed colleges and universities.

Experiment Stations

The first engineering colleges in the United States were virtually liberal arts colleges with a few subjects covering the art and science of engineering. As a result of the Morrill Act, land-grant colleges and universities were established in practically every state in the Union. In these institutions the engineering curriculum was given a place comparable with that of liberal arts and agriculture.

Beginning of Engineering Experiment Stations

With the engineering college as a separate entity, engineering research has developed in a wonderful way. The first regularly organized engineering experiment station was established at the University of Illinois on December 8, 1903. An engineering experiment station was established at Iowa State College in 1904. The number of engineering experiment stations has increased very rapidly since that time and there are at present thirty-six engineering experiment stations in land-grant institutions. In addition, there are a number of engineering experiment stations in state universities, not land-grant institutions, and a considerable number of engineering experiment stations in endowed colleges and universities.

State Experiment Station for Public Benefit

An engineering experiment station in a state university must carry on investigations for the benefit of industry and ultimately for the

benefit of the public. This limitation naturally restricts many of the investigations that can be undertaken by these experiment stations. In all coöperative investigations at the University of Illinois, the University reserves the right to carry on the investigations in its own way in its laboratories, with assistants employed by the University, and also reserves the right of publication. All inventions and discoveries belong to the University.

Pure Science Studies In carrying on engineering research, it is oftentimes necessary to develop new processes and new methods. If scientific knowledge is inadequate, it is necessary to carry on investigations in pure science in order that the problem can be solved. When structures and machines were of simple character, a knowledge of the common physical properties of steel was adequate for design and construction. With the increase in pressures, speeds, temperatures, and other necessary requirements in modern industry, this elementary knowledge of properties of materials was quite inadequate.

Appreciation of Engineering Experiment Station Research For several years at the University of Illinois, Prof. H. F. Moore has carried on investigations of the fatigue phenomena of metals. This investigation has been financed by the Engineering Foundation, the General Electric Company, and several other companies. The results of Professor Moore's investigation have given the Engineering Experiment Station and Professor Moore world-wide recognition. One of the members of the faculty of the University of Liverpool spent more than a year in Professor Moore's laboratory, and at present a professor from the University of Budapest is spending several months working under the direction of Professor Moore.

Industrial Coöperation While it is necessary that the permanent staff be supported by the state or by the institution, it is not possible to carry on all the needed lines of investigation in the Engineering Experiment Station without the coöperation of the industries. At the present time the State of Illinois is furnishing approximately $100,000 for the support of the Engineering Experiment Station. In addition to this, more than $150,000 a year is being furnished by the industries to carry on 32 coöperative investigations. These investigations are carried on with a staff of men working on full time, with a few men working on part time.

Training of Men for Industry Research graduate assistants at the University of Illinois are appointed for two years and give one-half their time to research and one-half their time to graduate study. More than one hundred of these research graduate assistants have completed their work and received the degree Master of Science. These men have been uniformly successful and are now occupy-

ing many positions of responsibility with the industries, in research, and with educational institutions. While the results of the researches carried on in the Engineering Experiment Station of the University of Illinois have been of great value to the industries, there is little question but that the men trained in the Station have been worth a great deal more than the data obtained in the investigations.

Ceramics at Illinois Station

Of the thirty-two coöperative projects now carried on in the Engineering Experiment Station of the University of Illinois, seven are coöperative projects in ceramics. These include (1) Aging of Porcelain, (2) Drying of Clay Ware, (3) Investigation of Feldspars, (4) Investigation of Clay Sewer Pipe, (5) Investigations of Enamels, (6) Boiler-Furnace Refractories, (7) Effect of Gases upon Combustion of Vitreous Enamels. The Department of Ceramics is, in addition, carrying on many other lines of investigation.

Two of the early bulletins published in coöperation with the State Geological Survey are "Investigation of the Fire Clay of the State," published in 1906 by R. C. Purdy and F. W. De Wolf, and "Paving Brick and Paving Brick Clays of Illinois," published in 1908 by A. N. Talbot I. O. Baker, C. W. Rolfe, and R. C. Purdy.

The publications of the Engineering Experiment Station include bulletins on "The Thermal Conductivity of Fire Clay at High Temperatures," "Dissolved Gases in Glass," "The Viscosities and Surface Tensions of the Soda-Lime-Silica Glasses at High Temperatures," "An Investigation of the Translucency of Porcelains," "The Measurement of the Permeability of Ceramic Bodies," "A Study of Hard Finish Gypsum Plasters," "An Investigation of Checkerbrick for Carbureters of Water-gas Machines," "The Thermal Expansion of Fireclay Bricks," "A Laboratory Furnace for Testing Resistance of Fire Brick to Slag Erosion."

Conclusion

In conclusion, may I express to the members of your SOCIETY our very great appreciation for your sympathetic support and coöperation in the training of men for the ceramic industry and in the solution of the many problems that are necessary in the development of the state of the art. While the principal duty of an engineering college is to train undergraduate students, it also has a responsibility to carry on research investigations and to train men for higher technical positions in industries and for positions as research investigators. In order that this latter work may be done, it is necessary to have funds for the stipends of the research graduate assistants and also contributions from industry to carry on coöperative investigations.

PAPERS AND DISCUSSIONS

THE GLASS TOUR, 1928

By Alexander Silverman[1]

In France

A. LaCroix On the morning of May 29, 1928, the entire Ceramic Tour party visited the plant of A. LaCroix, manufacturer of ceramic colors. This was especially interesting to the fifteen glass members of the Tour, because of the manufacture of purple of Cassius and other chemicals used for the coloring of glass. Purple of Cassius is manufactured at this plant by both the old and the thoroughly modern methods. Some people still insist on having it prepared by the older method.

Joint Meeting On the afternoon of May 29, the writer delivered an illustrated lecture on "Recent Developments in American Glass Manufacture" at the Maison Centreau on invitation of the Associated Ceramic and Glass Societies of France. The lecture was delivered in French before a group of five hundred members and delegates of these societies. T. S. Curtis of the Americans also read a paper.

Chantereine Plate Glass Works (St. Gobain) On June 1, we visited the giant Chantereine Plate Glass Works of St. Gobain at Thourotte, of which M. L. Delloye is director-general. This plant was a revelation in that it gave evidence of the thoroughly modern manner in which plate glass, whose process of manufacture was a discovery centuries before in France, is made there today. The plates are of enormous size, and every conceivable mechanical device for labor saving is in use.

Show Rooms On June 2, our party visited the show rooms of Lalique, Sabina, and others whose treasures in art glass production were available for inspection and purchase.

Nancy June 3 found us in Nancy with its public square and beyond this, the old palaces. In the square, one could not overlook the magnificent metal gates inlaid with gold, and the beautiful fountains.

On June 4, we visited the Crystallerie de Nancy, manufacturers of tableware and art glass in a variety of colors. We were also taken to the show rooms of Daum whose reputation in artistic productions equals that of Lalique and in some respects, surpasses it. Unfortunately, we were not permitted to enter the factory.

At noon, we left in a private bus for Strassbourg where we were scheduled to arrive that evening with plenty of time en route to visit the Crystallerie

[1] Presented at the Annual Meeting, American Ceramic Society, Chicago, Ill., February, 1929. (Glass Division.) (Contribution No. 180, Department of Chemistry, University of Pittsburgh.)

St. Louis. Certainly, all who rode on that 1900 model of an auto bus can never forget the trip. If our speed exceeded ten miles per hour it was on a down grade where neither brakes nor putting the machine in reverse had any effect. Needless to say, we reached St. Louis too late to visit the factory. A heavy thunder shower that came up forced us to put the cover over the bus, and after a few minutes we were compelled to raise our umbrellas under the cover. Every truck on the road passed us except one and the cheer that went up on that occasion would have been worthy of football fans at a moment of crucial victory by their team. We did reach Strassbourg and with all of our trials and tribulations felt satisfied because of the trip through the beautiful villages of Alsace-Lorraine.

In Bavaria

Deutsches Museum in Munich

On June 7, we visited the Deutsches Museum in Munich, the largest and most wonderful exhibition of the mechanical arts and sciences in existence. While the Conservatory of Arts and Measures in Paris is the oldest museum of this type in Europe and the Kensington Museum in London is another of the same type, the honors must go to the Munich institution. Exhibits cover every imaginable field of invention and practically every method of recovery and utilization of Mother Earth's treasures. The vastness of this display would beggar description were this entire paper devoted to the Deutsches Museum alone.

The quarters devoted to glass were just being equipped, but already had a very fair beginning in the way of a display of the furnaces and their products. Notable in the large room devoted to glass is the ceiling of glass mosaics presented by Puhl and Wagner of Berlin. It is symbolic of glass manufacture and carries a number of interesting themes. The value of some of the gifts to the Deutsches Museum may be imagined when the writer relates that on visiting the mosaic factory where this ceiling was made, he was told that it had cost over forty thousand dollars including the installation. Director Miller has a record unmatched and not even approached when one considers the extent and value of the exhibits that have been given to this museum. The writer understands that the museum buys nothing and that everything has been presented.

Carlsbad

June 9 found us in Carlsbad, the attractive kur located in the depths of a beautiful valley surrounded by high mountains.

Moser

In Carlsbad are the show rooms of Moser, another manufacturer of tableware and art glass of a very high order. Moser's plant was open to the party, and here one could see a variety of off-hand work. Moser is producing the new Alexandrite glass which is colored with neodymium oxide shading from pale lilac to a deep heliotrope, according to the play of light upon it. It is one of the few new colors that has been

produced in glass in many years and has a brilliance and attraction rarely found in colored crystal.

Brockwitz On June 14, we visited the Brockwitz factory at Sornewitz near Meissen where cheap pressed tableware and vases are the products. This factory does interesting enameled lettering and design work on beer glasses and hotel ware. It seems unbelievable that such pretty work in colored enamel can be produced for a mere song.

In Berlin

Hochschule Berlin was our headquarters from June 15 to 18, inclusive. Here we visited Dr. K. Endell's laboratory in the Technische Hochschule. Endell is prominent for his work in the field of glass and ceramics.

Osram Lamp Works In Berlin we also visited the Osram Lamp Works where Dr. G. Gehlhoff is director. They employed Westlake Bulb Machines which are less modern than the process now in use by the Corning Glass Works in which a continuous sheet is rolled that has lens-like protuberances from which the bulbs are blown.

Gehlhoff's factory was an example of the most complete technical control in evidence anywhere in Europe. Here, raw materials cannot be introduced into the storage bins until they have been tested in the laboratory, as the chief chemist is the only individual who has a key to unlock the bins. They are weighed on portable scales with concealed beams. The individual who weighs the raw materials must push a button on the machine to make a record for each weighing, and this button will not operate unless the scale is in perfect balance.

The furnaces are under pyrometric control, checked by optical pyrometers.

The machines are under the supervision of a foreman, but all adjustments are made by expert mechanics who are authorities on the Westlake machine.

Imperfect bulbs are dropped through pigeon holes, each of which is provided with a pendant which records the number of imperfect bulbs passing through. There is one receptacle for cordy glass, another for stony, a third for bulbs of improper thickness, etc.

The producer gas is cleansed by an electrical precipitator and we were told that the tarry liquor that resulted brought a sufficient price to decrease the cost of gas very appreciably.

Gehlhoff's plant affords an admirable example of the application of science to industrial control.

Wegener Glass Collection In Berlin a few of us had the privilege of viewing the collection of Chinese glass of Frau Olga Julia Wegener, wife of the famous oriental geographer, Professor August Wegener. While the collection consists of less than fifty pieces,

many of the specimens are the only ones of their kind outside of China. One in particular was noteworthy for its deep cutting of a recessional type. Cutting usually results in a beveled edge, or perhaps a straight cut, but in this article the tool proceeded back of the original line of cutting and into the glass. Mrs. Wegener's collection has been appraised at about sixty thousand dollars.

Potsdam Palace Nor must we overlook the extraordinary glass chandeliers in the former Kaiser's Palace at Potsdam as well as other art treasurers of a vitreous nature.

Kaiser Wilhelm Institut The Kaiser Wilhelm Institut für Silikatforschung with its complete layout of laboratories for physical and chemical testing and research in the glass field occupied the party for the greater part of the morning. The Institut is better equipped for this work than any other institution we visited in Europe. Dr. Wilhelm Eitel, also professor in the technical high school of Charlottenburg, is director. It was here that didymium, neodymium, and praesodymium glasses were developed to say nothing of other colors and glasses that had to possess special physical properties. The Institut is the outstanding laboratory of pure research in the glass field and is, of course, a German government institution, independent of educational or industrial control.

Puhl and Wagner It was the writer's privilege on his return to Berlin some weeks later to visit the glass mosaic factory of Puhl and Wagner in the suburb of Treptow. Here, every conceivable shade and tint is produced including cased crystal inclosing gold, silver, etc. While the glass manufacture itself is a small-scale casting operation, the production of mosaic pictures is conducted on a very large scale. Beautiful murals and panels were in progress for ultimate transportation to many foreign countries.

Berlin Museums One must mention the Schloss and Altes Museum in Berlin. The latter houses the famous Adolph Schiller collection of ancient glass which is to be auctioned shortly; also, the von Gans and Maria von Rath collections.

Bicheroux Plate Glass Some of the party took a side trip to Herzogenrath on June 19 to visit the Bicheroux Plate Glass Factory which employs six hundred men and has a capacity of eighty tons per day. This factory employs the twin plate process which has already been described in the literature.

In Holland

Haag Museums On June 20, we were in Scheveningen and Haag, Holland. The museum in the latter city guards the famous paintings of Van Dyke, Rubens, Franz Hals, and others. But it also contains an attractive variety of modern Dutch glass, and especially

the exquisite old goblets and vases whose designs were stippled with a diamond point. No modern etching or engraving compares with the delicacy of the stippler's art.

In England

United Glass Bottle And now we come to the last lap of the trip; namely, the portion spent in England. On June 21, we visited the United Glass Bottle Manufacturers, Ltd., at Charlton where bottles are blown by machine.

General Electric June 22 was crowded with a program that may seem impossible to the reader. We visited the large research laboratories of the British General Electric Company at Wembley, where much work is under way on the study of glass for the manufacture of various kinds of bulbs for lighting and radio. The British call the latter valves instead of tubes, and manufacture a larger type than we use so as to utilize the standard glass bulb from lighting units and obviate the necessity of making special shapes for radio purposes. The research laboratories are remarkable, and impress one first, for their immaculate cleanliness, and second, for the compactness and ingenuity of design of equipment for photometric and other physical testing. Mr. Wilson, the president of the company, was our host at luncheon, and Mr. Patterson was untiring in his efforts to enlighten us on the details of the research department. From the research laboratories, we went to the bulb factory at Wembley where Westlake machines are in use and the procedure is much like that of the Berlin factory.

James Powell and Sons That same day we also visited the factory of James Powell & Sons, manufacturers of art and tableware entirely by the hand process. This was quite in contrast to the modern equipment of the bulb factory we had just visited, for at Powell's the furnaces are of the old type; the large melting pots are surrounded by a number of small crucibles or open tubes containing the special glasses which are used for casting, flashing, or decoration. Double doors lead to the blowing room and we were warned to close the outer doors very carefully before opening the inner ones so as to avoid a draft in the blowing room. The artisans, seated at their work-benches, get most of their light from the furnaces and also considerable smoke. The plant is a typically old-time plant, having none of the copious ventilation that is evident in our American factories. One would almost think that he had gone back a century when he enters the Powell plant at Harrow, but the ware is beautiful, the colors are good, the products are artistic.

Rockware Glass The Rockware Glass Syndicate, Ltd., at Greenford was also on our program.

Stourbridge On Tuesday, June 26, we were given two unusual treats in Stourbridge, first, visiting the plant of Thomas, Webb

& Corbett at Wordsley, famous for its rock crystal glass and exquisite table ware and, second, the plant of Stevens and Williams at Brierley Hill which has the finest aggregation of cameo engraved and cut glass that it has been the writer's privilege to view in a single show room. Both of these plants employ artisans and real artists. At the latter plant, one had to note the remarkable virility of Mr. Silver Williams-Thomas, who although eighty-three years of age, is still active in the management of the company. Here also is John Northwood, famed for his Aphrodite cameo plate and other engravings. This was a memorable day.

Dr. J. W. Mellor On Wednesday, June 27, in the famous old pottery center, Stoke-on-Trent, we visited the laboratories of the distinguished ceramist and chemist, Dr. J. W. Mellor. This genial host with his keen sense of humor is one of the most productive workers in the two fields already mentioned. Nor must we forget Mrs. Mellor whose keen business sense and management are largely responsible for the publication of Dr. Mellor's books. Mrs. Mellor keeps a corps of stenographers busy constantly on the doctor's work.

Wedgwood That same day, we visited Josiah Wedgwood's factory. It may seem strange to mention this in connection with a report on glass, but it must not be forgotten that it was Josiah Wedgwood, the artist and master potter, whose third model enables us to possess replicas of the famous Portland vase of the first century, Rome, that rests in the British Museum. Sir Joshua Reynolds pronounced Wedgwood's third model perfect.

Dr. W. E. S. Turner Thursday, June 28, we visited the modest quarters of the Department of Glass Technology at Sheffield where Dr. W. E. S. Turner, known to every American glass man, is in charge. With limited funds available, Dr. Turner converted an old factory building into a department of instruction. What is most important, this department is turning out more research today than any other single laboratory in the world, and the research is significant.

Glass Works in Yorkshire District June 29 was another big day, including the factory of Jackson Brothers at Knottingley; John Lumb & Company, Castleford; Beatson Clarke, medical bottles, at Rotherham; Wood Brothers, medical bottles, chemical ware, etc., at Barnsley; Redfearn Bottle Works at Barnsley; and the factory of Hailwood and Ackroyd at Morley. The last named are engaged in the manufacture of illuminating ware of a large variety of types, and have the most spacious and modern plant of its kind that the writer visited in Europe. They apply a principle that we might well emulate in America, for they use small furnaces containing several pots each or small tanks and are thereby enabled to make a large variety of glasses, allowing each to melt at a suitable temperature and with a suitable temperature gradation and

time period. In addition to their glass factory, Hailwood and Ackroyd have an enormous shop for stamping patterns from which they manufacture lighting fixtures. They are also engaged in the manufacture of safety lamps, some of which are exceedingly ingenious.

Hospitality Acknowledged On June 30, the American ceramic group made their departure for America. The reader is reminded that hospitality and attentions were showered upon us everywhere. We were on the go morning, noon, and night. We were wined and dined everywhere. Our hosts were so gracious and hospitable that their efforts are impressed upon all who were fortunate enough to be their guests as members of the American Ceramic Tour in Europe.

On My Own in France

After the party left, it was the writer's good fortune to visit a number of other glass centers about which he wishes to report in connection with the Ceramic Tour.

Marcelle Goupy First mention is made of the show rooms of Marcelle Goupy in Paris whose relief enamels on glass are distinctive for their art, beauty, color, and decided originality. Some rare old Venetian glass not seen in any other museum in Europe is in the Cluny Museum.

Conservatory of Arts and Measures Again, the Conservatory of Arts and Measures in Paris houses the most representative collection of modern glass in Europe as well as that famous life size serpent stifling a lion, made entirely of spun glass by Lambourg which required over twelve years for its completion and has been in the conservatory since 1865.

Can one mention Paris without referring to those wonderful stained glass windows in St. Chapelle?

In London

British Museum A second visit to London afforded the opportunity of visiting the British Museum with (in addition to the Portland vase) its wonderful collection of ancient glass and a large display of products of the Middle Ages and the Renaissance Period. Especially noteworthy are the old English and Irish glasses, and further examples of the diamond stippler's art which was mentioned in connection with the museum at the Haag.

An even finer collection of English glass is to be seen in the Victoria and Albert Museum. This exhibit includes a wine glass where the entire graving was done with a diamond. It is inscribed, Barbara Potters 1602. It is the only glass of its kind that the writer has ever seen, and is in perfect condition.

Cathedral Windows The stained glass windows in many of the churches of England are particularly fine and attractive, but the writer was especially impressed with the old windows in Christ Church, Oxford, and in the Chapel of New College, Oxford.

In Rome

Vatican Museum In Rome, there are two collections of special merit; first, that in the Vatican Museum which includes the largest assemblage of Christian cemetery glasses of the Twelfth Century in existence. These were found imbedded in the walls of Roman tombs in which the Christians buried their dead. They contain various religious motifs in gold leaf which is sealed between two layers of glass. The original medallions were the bottoms of dishes that were imbedded in the wet cement of the tomb walls. They have become broken and only the medallions are left.

Diocletian Museum In the Diocletian Museum are some of the rarest of treasures among the ancient glasses representing every conceivable shape and color that was made in Rome, Byzantium, Greece, and Egypt. The details of some of the mosaics and Millifiori glasses are very delicate and attain a perfection that seems incredible. The method of display of the colored medallions in this museum is unique in that they are housed in cases backed with frosted glass and set into the window frames of the display room so that the light shines through and shows the colors in their full splendor.

We cannot leave Rome without referring to the exquisite windows in the churches; there is not time here for a detailed account, and an entire article or even volume might be devoted to stained glass windows alone.

In Florence

Florence, the ancient capitol of the republic by that name, has the Pitti Palace, the last home of the Medici which is noted for its real rock crystal. Here in the Museum of Natural Science, one finds the thermometers, barometers, and other scientific instruments in glass employed by Galileo. They are evidently of Venetian manufacture, for the thermometers are ornamented with frail wings and delicate scrolls typical of Venetian artisanship. Even the beakers and flasks have decorations in crystal and color.

In Venice

And then there is Venice with the Salviati Museum, and the adjoining island of Murano with its Street of the Glassmakers.

Remember that the Venetians melt their glass in very small pots surrounded by tiny open crucibles bearing the various special colors. Their

furnaces are wood fired. It is common in their delicate fancy creations to apply a dozen or more colored parts to a single article. This means constant re-warming to soften the glass sufficiently to make the various parts adhere. There are no modern annealing ovens like those employed in American factories. The finished articles are placed in a covered runway which rests on top of the small melting furnace and are shoved slowly down the slightly inclined floor to the exit. Considering the variety of glasses employed and the necessary differences in expansion, together with the differing designs of the various parts of an article and the crude method of annealing, it is nothing short of remarkable that the finished article is durable instead of flying to pieces.

Barovier Glass Works While it was the writer's privilege to visit a number of the famous Muranese factories, he is inclined to single out that of Barovier where the most artistic and valuable of modern Venetian glass is made. Here the blind father, Benvenuto, though still living, has assigned the duty of continuation of manufacture to his sons. The art creations of Benvenuto Barovier in glass promise in time to take their place with the products of the old masters in the field of painting. They are the more remarkable in that all the decoration was effected by melting-in particles of colored glass, a task more difficult by far than could be encountered in the painter's art.

Fratelli Toso operate the second plant which is given special mention because of the interesting reproductions of ancient glasses which are produced at this factory.

Museum in Murano When you go to Murano, you must visit the museum where you will have to knock to gain admission and then be taken up to the display rooms by the lone guardian who raises the shades one at a time so that you may see the exhibits. Here you will gain a good knowledge of the history of Venetian glassmaking, and be especially impressed with the work that was done by assembling tiny rods of colored glass as small as pencil leads or even smaller, melting them together and even drawing the softened unit out so as to produce minute medallions, bearing designs that are beautiful but invisible without the aid of a magnifying glass. These are worked together in paper weights and various other objects, sometimes Millifiori plates, etc.

In Jena

Dr. Schott Another stop and we are in Jena, greeted by the genial smile of Dr. Otto Schott, the greatest living glass chemist, in fact the greatest of all time in the field of glass technology and research. Although seventy-seven years of age, he is still instrumental in directing work at the famous plant of Schott and Genossen. Here one of his sons is associated with him.

Jena Glass Works The plant manufactures a large variety of ware and is by no means limited to the production of laboratory and thermometer glasses. One sees the manufacture of mercury arc rectifying bulbs in all sizes and up to enormous dimensions, direct current meters, and even glass dinnerware. The new designs in laboratory ware are interesting and the researches that are in progress on colored glasses and crystal that shall meet special physical requirements indicate that Jena has never stopped progressing. Here also is the Abbé Memorial and the Zeiss School for Optics to which students migrate from all parts of Europe. There is also the famous old University of Jena.

In Belgium

One more stop. Just outside of Liège, Belgium, is the huge factory of Val St. Lambert, where from the viewpoint of general manufacture of tableware and art glass, one sees the finest variety of crystal and colors of high quality to be found any where today. The cuttings and engravings are superb. The perfection of the glass and its resonance are exceptional. This company employs over forty-five hundred men and women and at the celebration of its centenary last year awarded medals to over fifteen hundred employees who had served the company twenty-five years or more. Many of these employees have been with Val St. Lambert thirty-five or forty years, and one woman has been serving for over sixty years. The beaming faces of the workmen indicate that theirs is a labor of love. Many families have served the company through three or more generations and while the technical staff is engaged in the perfection of color and quality, the almost faultless product created in artistic fashion is undoubtedly due to the tradition that has come to those who mold the glass into the various creations. It is not uncommon in this plant to see three or four colors worked layer upon layer into a finished product that displays even a greater play of color through the skill of the cutter and engraver.

Conclusion

The final paragraph is most appropriately a tribute to Ross C. Purdy, Secretary, AMERICAN CERAMIC SOCIETY, whose plans and labors afforded a Ceramic Tour whose content was so great as to seem incredible in so short a period as five weeks; and it is also appropriate to express the appreciation of the glass group for the whole-hearted coöperation given by the manufacturers, directors of museums, officers of European societies, and officials in the various centers visited.

DEPARTMENT OF CHEMISTRY
UNIVERSITY OF PITTSBURGH
PITTSBURGH, PA.

BICHEROUX PLATE GLASS PROCESS[1]

By J. Earle Frazier

On June 19 of last year, Dr. Ralph O. Smith, of the Salem Glass Works, and I left our party at the Breidenbacher Hof Hotel in Düsseldorf, Germany, and proceeded to Herzogenrath, Germany, which village is one and one-half hours' run from Düsseldorf.

We were kindly received at the Factory of Max Bicheroux & Company, G.m.b.H., by Lambert Reis, the Chief Engineer.

The factory employs between 500 and 600 people and supplies them with homes which they are permitted to keep as long as they care to, whether they are dismissed from employment or not. The plant does not work on Sundays, which is unusual in plate glass manufacture. The factory consisted of four 20-pot furnaces of about eighty tons capacity each or three hundred twenty tons over a twenty-four hour period, six days per week.

Comparison with Old Method

The glass in both processes is taken out of the furnaces at temperatures of around 2000°F and poured at about 1900°F. By the time it goes into the leer it is down around 1300 to 1200°F.

In the old method, the glass was dumped from the pot onto a stationary casting table and a water-cooled roller run over the gob of metal rolling it out into a flat sheet from $^{15}/_{32}$ to $^{1}/_{2}$ inch in thickness. The roller was elevated a few inches and the sheet was pushed into a leer three or four hundred feet long. From there the sheet was picked up by a vacuum device and then placed on a 30- to 36-ft. grinding and polishing table. This grinding process requires about 60 to 65 minutes, while the polishing requires from 100 to 115 minutes.

The Bicheroux process consists primarily of two water-cooled rollers in position, the one above the other with the upper roller attached to a movable receiver. It also has a moving casting table.

The pot of glass is poured onto the movable receiver when the receiver is in a horizontal position. The receiver, with the front end hinged, is then slowly elevated or tipped forward. The upper roller likewise moves forward and the glass is fed into the revolving rollers. The revolving rollers deliver the glass as a sheet down an inclined plate or chute onto a moving casting table running at a speed corresponding to the speed of the glass coming down this inclined chute. The inclined chute is adjustable, forward or backward. There are also tiltable guide rollers to assist in keeping the glass sliding down the inclined chute to the casting table.

From the casting table the glass is delivered to a leer and from there it

[1] Presented at the Annual Meeting, American Ceramic Society, Chicago, Ill., February, 1929. (Glass Division.)

is placed on continuous grinding and polishing tables. During this continuous grinding and polishing there is then an intermediate step which enables the sheet to be turned over after it is polished, and the grinding and polishing is then started on the other side. Lambert von Reis has developed the machinery for the continuous grinding and polishing.

At the Herzogenrath works, the sheet is cast with fluted bottoms, or finely-grooved bottoms, so as to avoid flat contact with the surface of the leers. The thickness of these cast sheets is $6^1/_2$ mm. After the grinding and polishing is applied, the thickness is 4 mm. The loss is approximately $2^1/_2$ mm. of glass. In the English system the cast sheet is $^1/_4$ inch, while polished it is $^5/_{32}$ to $^1/_8$ inch.

The saving resulting from this process is very considerable in the grinding and polishing time. The grinding time is about 30 minutes, while the polishing time is about 60 minutes; a saving in grinding time of 30 to 35 minutes and in polishing time of 40 to 55 minutes.

There is also a saving in labor necessary in the preparation of the sheet for grinding and polishing.

The big feature of the process is that 40% mirror quality is claimed, while with the old process and other processes in America 12 to 15% mirror quality is considered very good. Perhaps the biggest feature is thinner, more even sheets that are straighter and flatter at a greater speed and at a lower cost.

This plant experiences about 22 melts to a pot. It has tried to work with cast clay pots but has not succeeded thus far.

The plant produces 700 sq. ft. per hour and packs 620 sq. ft. per hour. The loss from cutting table to pack is 12%. Most manufacturers figure 20 to 30% loss for breakage, etc., over what the plant is capable of producing.

A great step for someone to make is a continuous grinding and polishing machine that will actually work satisfactorily on both sides of the sheet at the same time.

After being entertained at Mr. Reis' home, Dr. Smith and I joined the rest of the party at Düsseldorf and from there we went to Holland.

SIMPLEX ENGINEERING COMPANY
WASHINGTON, PA.

GLASSHOUSE REFRACTORIES OF EUROPE[1]

By C. E. Fulton

This is not a formal paper covering the glasshouse refractories which we saw during our tour of Europe. A few impressions of several operations in France, Germany, and England which were of special interest are presented.

St. Gobain Co.

The Chantereine plant of the St. Gobain Company at Thourotte in France was interesting throughout. It is a modern plate glass plant in every sense of the word and uses every modern mechanical means of reducing to a minimum the heavy manual labor of plate glass manufacture.

The plant as a whole covers about 155 acres and is built of reinforced concrete. It is situated on the banks of the river Oise and most of the raw materials are received in boats from which they are delivered to the plant by an aerial conveyer system.

Manufacture of Pots

The preparation of the pot batch and the manufacture of their pots is quite different from the process used in this country. The raw clays and grogs, of which there may be a dozen or more, are each crushed and ground separately and then elevated to a screen. This screen is located above and in the center of a large hollow cylindrical concrete storage bin, which is divided vertically into about twelve compartments. These compartments are of a rather narrow cross-section and thus keep down to a minimum the separation of the coarse and fine particles. A swinging chute mounted under the screen permits the delivery of the material to any desired compartment.

Underneath this large bin the materials are delivered to a hopper connected with a scale. Underneath this hopper is a transfer car which, when all the ingredients of the pot batch are weighed into it, is taken to an elevator and raised to a platform located above a large Werner & Pfleiderer kneading machine or mixer. The materials are dumped from the transfer car into this mixer and the necessary amount of water added and the batch mixed for approximately 20 minutes. The mixer is then tilted and the batch removed and fed to a small blocking machine. From this machine the wet mixed batch is piled on a truck and taken to the aging cellar where it is kept in a moist condition for a period of from two to three months.

After this aging period, it is used in the building of their pots. The pots are oval in shape, about 75 inches long, 50 inches wide, and 30 inches high and weigh about two tons. In building the pot, a large two-piece wooden mold is used to give the outside dimensions.

The bottom of the pot is first built up by hand to a thickness of 15 or 16 inches. The wooden mold lined with a piece of cloth is placed around this

[1] Presented at the Annual Meeting, American Ceramic Society, Chicago, Ill., February, 1929. (Glass Division.)

bottom and the pot maker begins to beat a hole in the center portion with a large heavy beater and gradually works the clay against the sides of the wooden mold.

When the bottom portion has been beaten to a thickness of approximately 7 inches and the excess pot batch worked up the side of the mold, the remainder of the side wall is worked in by hand. When finished, the pot has a bottom thickness of about 7 inches and a side-wall thickness of 6 inches.

A pot maker and his helper complete one pot in a day. The pots are made in individual drying rooms holding about 25 or 30 pots and after being finished, they are covered with cloths and the temperature and humidity carefully regulated during the drying period.

As a rule the pots are not used until from four to six months after being finished. The average life of the pots was said to be about twenty days.

A similar grinding, screening, storage, and mixing installation located alongside the pot batch equipment is used for preparing the refractory batches. These batches are used in making their own furnace stone, tile, and other refractory shapes required in the manufacture of glass.

Schwepnitz and Kamenz

When we arrived in Germany we wished to see some pots made by the casting process as I understood they had been using this process for a number of years. Dr. Schwartzkopff (through Dr. Endell) volunteered to take us to Schwepnitz and Kamenz where we could see this process. Dr. Emil Weber who was the first to make pots by the casting process, took us to a plant where all the pots were being made by this process.

In this plant one man did all the work of weighing out the batch, mixing the slip, and casting the pot. He made from six to eight pots per day according to the plant requirements.

The various ingredients in the ground condition were weighed by this man and put into a concrete bin where it was given a preliminary mixing by being turned over several times with a shovel. From here it was put into a screw conveyer and elevated to the blunger or the mixing tank where the required amount of water and electrolyte were added.

The mixing was completed in half an hour and the plaster mold forming the outside of the pot and a plaster core forming the inside and both clamped to a plaster bottom board which rested on a small truck was run under the opening in the lower side of the blunger. A metal spout was hung over the edge of the plaster mold and the slip directed against the side of the mold. The operator rocked the mold while the slip was being added. After being filled with slip, the mold was taken to the drying room, the core being removed after 24 hours and the outside mold after 48 hours.

The pots which were of the open top variety, were rather small, being approximately 33 inches in diameter and 30 inches deep with $2^3/_4$-inch walls and 3-inch bottoms. In service it was stated that they lasted from six to eight weeks and were used for melting glass to be made into various kinds of bottles.

The plaster molds, some of which Dr. Weber stated had been in use for six years, were quite thin and light and thus easy to handle. The outside was in three sections and the thickness was only about 2 inches. Each section was in a metal frame and in setting up the mold, the sections were clamped together and also clamped to the bottom board. The core was hollow and also about 2 inches in thickness with a metal frame and this also was clamped rigidly in place. The slip was quite fluid although it contained only 18% water by weight.

Plant at Thonberg

From Schwepnitz we went to the plant where Dr. Schwartzkopff was in charge. This plant is located at Thonberg just outside of Kamenz. The manufacture of tank blocks by the casting process had been started recently at this plant. The slip preparation was similar to that already described except that a somewhat thicker consistency was used, the water content being reduced to about 16%.

In order to have a supply of slip always available, a second blunger or agitator was used. This was a long semicircular trough which appeared somewhat similar to the open-top horizontal pug mills used in this country.

From this agitator the slip was run into a semicircular transfer car with a hand-operated stirrer. This was mounted on three wheels and was pushed around by the operator to the tank block molds which were placed on the floor in a large room.

This transfer car was propped up at an angle by the operator and the gate was opened at the lower end and the slip run into the molds. The operator held a wooden paddle about 4 inches wide in the slip stream so that it did not strike the mold in one place. This paddle was also used to level the slip and to see that it filled all the corners.

Except when very large blocks were being cast, this transfer car held sufficient slip to cast several blocks. After casting a block, the remaining slip in the car had a tendency to thicken and before casting the next block, the operator worked the hand stirrer in order to have the slip in a fluid condition.

The dried tank blocks did not show any settling and required very little dressing. They were fired in downdraft kilns to cone 14. A very convenient one-man lift truck was used to transport blocks weighing as much as half a ton.

The construction of the plaster molds was quite simple. The bottom portion consisting of tongue and grooved plaster board which was purchased from the manufacturer in long lengths about 12 inches wide and 2 inches thick and was sawed to the proper length for the individual molds. The side walls were formed from 1-inch thick plaster board nailed on the inside of the wooden molds.

Scheidhauer and Giessing

While in Düsseldorf, Germany, Dr. Herman Knuth took several members of our party to one of the plants of Scheidhauer & Giessing Company where they were making large refractory shapes with only 10% of raw bonding clay. This is a patented process and it consists in deflocculating the raw clay completely and mixing it to a thin consistency in which state it is aged for about 24 hours.

In preparing the batch the ground and sized grog mixture is first put in a large Werner & Pfleiderer mixer and the fluid deflocculated raw clay run into this mixer. When removed from the mixer, the batch is in the condition of a semi-dry press mixture and the large shapes are made by ramming with an air hammer in metal molds. Bricks were also being made on a power press.

It is claimed that due to the small amount of raw clay, there is practically no drying and firing shrinkage, and the trueness of the ware after being fired bore out this statement. In spite of the small amount of raw clay used, the ware all appeared to be well bonded and by varying the grog sizing Dr. Knuth claimed that they could make either an open porous refractory or a comparatively dense body.

Sillimanite Pots at Sheffield

In England we saw some sillimanite pots made and used under the direction of Dr. Turner which he stated had given remarkable service. These pots, however, were of a laboratory size.

E. J. and J. Pearson Co.

Much of the clay work in England was similar to our own practice except the manufacture of tank blocks as seen at one of the plants of E. J. & J. Pearson Co. This plant was using the well-known "Stourbridge" clay and the batch was composed of 50% grog and 50% raw clay. The raw clays used were not washed, but were weathered for six months to a year and the batch after being prepared was aged for six months.

Each block maker tempered his own batch in a small pug mill to the working consistency that he preferred provided it did not contain under 16% of water or over 18%.

Wooden molds were used and the batch was not thrown as is the custom here, but was worked in by hand. As a general practice the blocks were dressed green but for some special customers they were dressing a few blocks after firing. The blocks were fired in large circular downdraft kilns to cone 14 and after firing it was stated that they had a porosity of about 18%.

The entire tour was most pleasant and interesting. In every country which we visited, we were royally entertained and every effort made to show us whatever we wished to see.

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ACTIVITIES OF THE SOCIETY

JOSIAH WEDGWOOD BICENTENARY

The Ceramic Society of England has planned a three-day celebration of the anniversary of Josiah Wedgwood's birthday in Stoke-on-Trent, May 21, 22, and 23, 1930. The preliminary agenda are as follows:

Wednesday, May 21

(M) Welcome by Lord Mayor and wreath on Wedgwood's grave.
Lunch.

(A) Garden Party (Major Wedgwood).
Oration on Wedgwood—Hobson.
Brief remarks by Mr. B. Moore.

(E) " " " Mr. J. Burton.
" " " Dr. J. W. Mellor, F.R.S.

Thursday, May 22

(M) Receive representatives and address from foreign kindred societies. (The United States, France, Germany, Czechoslovakia, Italy, India, Japan, Sweden, etc.).
Luncheon—Chamber of Commerce.

(A) Visit Wedgwood's Works.

(E) Dinner of Ceramic Society (all sections).
Presentation of prizes to winners of essay competitions.

Friday, May 23

(M) Meetings of Sections (Pottery, Refractory, and Building).

(A) Ditto.

(E) Popular Lecture.

(General, Council, and Committee meetings to be adjusted).

JOSIAH WEDGWOOD

The Passion Play Oberammergau in Bavaria

The Oberammergau Passion Play has no parallel in modern times as a religious drama rooted in faith and piety and presented in a manner which has commanded world-wide attention, admiration, and respect for the devotion of the performers. The dates of this play naturally make this a part of every tour planned abroad.

The dates of presentations will be
May 11, 18, and 25.
June 1, 9, 15, 22, and 29.
July 2, 6, 9, 13, 16, 20, 23, 27, and 30.
August 3, 6, 10, 13, 17, 20, 24, 27, and 31.
September 3, 7, 10, 14, 21, and 28.

Wedgwood Celebration and Stoke-on-Trent

The Ceramic Society of England has invited Americans to participate in the Josiah Wedgwood bicentennial celebration. They will arrange for plant visits at Doulton, Meakin, Maddock, and Wedgwood potteries.

To see the Science School of Stoke-on-Trent which Dr. J. W. Mellor directs and which is the Ceramic School of Great Britain is a treat for which many ceramists have longed. They all go there. It is a pilgrimage to Dr. Mellor, the chemist and ceramist peer of world renown.

But of more vital interest is the old pottery shop, the bench and the wheel where Josiah Wedgwood worked and created. These are preserved.

Josiah Wedgwood's laboratory note books, his trial pieces, his early products, and those which made him world famous will be shown. No greater, more artistic, and more scientific potter ever lived. It is enthralling to speculate what he would have accomplished had he had available the art and science of the present day. His works are today modern. They continue as the vogue. He has not been surpassed. It will be an inspiration to see where this potter two centuries ago worked and produced.

Transportation Thomas Cook and Sons Co., Ltd. has charge of the transportation. They are planning tours through the British Isles, Bavaria, and other points of ceramic interest. Details regarding these are being developed. The important thing is to fix the week of May 18, as the beginning of your 1930 tour abroad. It is of immense ceramic interest.

CERAMIC EXPOSITION

Chicago's Century of Progress Exposition 1933

Under the direction of the National Research Council a great exposition of "Century of Progress" in science and industries is being planned. The AMERICAN CERAMIC

SOCIETY has been asked to take leadership in organizing an exposition of ceramic ware which will tell (1) the progress made in 100 years of ceramic producing, (2) the contribution by ceramics to progress of other industries, and (3) the contribution to the century of

progress in ceramics by other industries and by science discoveries. This same sort of exposition is being arranged for all sciences and industries.

The accompanying chart shows how these exhibits are to be arranged by periods so that each circle will show contemporary development in science and industry during a definite period, and each sector will show progressively the advancement in particular lines within each of the time periods.

This exposition is to cover all ceramic industrial lines and be world wide in representation. All ceramic trade associations and the ceramic societies in each of the industrial countries abroad will be expected to share alike in responsibility for making this ceramic exposition most representative and instructive.

Ceramic Congress

The Chicago Exposition Executive Committee has asked the AMERICAN CERAMIC SOCIETY to organize an international congress for the discussion of ceramic art, science, and technological problems. No details of the plans for this have developed except that it shall be strictly international.

A great opportunity but an immense responsibility is put onto each and all members of this SOCIETY. We must make our ceramic friends abroad realize that this will be their congress and not alone that of Americans. The Ceramic Associations of all countries will be asked to share alike in joint sponsorship of this Congress of "Century of Progress" in ceramics.

NEW MEMBERS RECEIVED FROM AUGUST 1 TO SEPTEMBER 1

PERSONAL

Louis Douin, Charcas 926, Buenos Aires, Argentina, Enameler.
Dwight B. Hendryx, 5546 Darlington Road, Pittsburgh, Pa., Engineer, Harbison-Walker Refractories Co.
Björn Holmström, Mäster Olofsgatan 9, Golfe, Sweden, Ceramist and Engineer, Golfe Porslinsfabriks Aktiebolag.
Fortunatus Quartus Mason, 206 Broadway, East Liverpool, Ohio.
Yoshiyuki Morimura, Kokura, Fukuokaken, Japan.
William Norbert Neff, Neff Ceramic Co., 801 Central Bldg., Pasadena, Calif.
Harry C. Payne, Route 1, Box 93, Concord, California, Manager and Enameling Superintendent, Porcelain Enameled Products Co.
Walter Pohl, Siegersdorf (Kreis Bunzlau) Germany, Direktor der Siegersdorfer Werke vorm. Friedr. Hoffmann A.-G.
John C. Reed III, 3706 Brighton Road, Pittsburgh, Pa., Research Engineer, Standard Sanitary Mfg. Co.
A. D. Whipple, P. O. Box 643, Alexandria, Ind.

Membership Workers' Record

PERSONAL

Robert C. Boyd	1
W. N. Harrison	1
J. Spotts McDowell	1
R. E. Stark	1
W. W. Wilkins	1
Office	5
Total	10

ROSTER CHANGES IN AUGUST

PERSONAL CHANGES*

Blackburn, Harry A., 2713 Hampshire Road, Cleveland Heights, Ohio. (1450 Rockway Ave., Lakewood, Ohio.)
Du Bois, H. B., Consolidated Feldspar Corp., East Liverpool, Ohio. (Pennsylvania Pulverizing Co., 323 Fourth Ave., Pittsburgh, Pa.)

* Addresses within the parentheses () represent the old address.

Foster, Harry D., Engineering Experiment Station, Ohio State University, Columbus, Ohio. (161 Orchard Ave.)
Hahn, Carl A., Parker Russell Mining and Mfg. Co., St. Louis, Mo.
Hope, Herford, Devonmoor Art Pottery Co., Liverton, Newton Abbot, Devon, England. (Coline Brick & Terra Cotta Co., Ltd.)
Hudson, Charles J., Research Laboratories, Norton Company, Worcester, Mass. (39 Kingsbury St.)
Lyttle, Frobisher T., Monmouth, Ill. (503 Convers Ave., Zanesville, Ohio.)
McAfee, W. Keith, 315 East St., New Castle, Pa. (Universal Sanitary Mfg. Co.)
Mong, Lewis E., 2039 Park Rd., Washington, D. C. (3916 Legation St.)
Parkhurst, Howard M., 4138 Washington Blvd., Chicago, Ill. (1395 E. First South St., Salt Lake City, Utah.)
Parmelee, Cullen E., Carrier Engineering Corp., 1824 Union Trust Bldg., Cleveland, Ohio. (Land Title Bldg., Philadelphia, Pa.)
Pearson, J. Donald, 107 Parkwood Blvd., Mansfield, Ohio. (522 College St., East Liverpool, Ohio.)
Salisbury, Bert E., 412 Berkley Drive, Syracuse, N. Y. (1810 W. Genesee St.)
Saylor, Raymond B., American Sheet and Tin Plate Co., Wellsville Works, Wellsville, Ohio. (603 Lexington Ave., Sharpsburg, Pa.)
Schoots, Walter H., 100 W. California Ave., Columbus, Ohio. (468 Vermont Place.)
Simmons, Robert M., 2045 Las Colinas Ave., Los Angeles, Calif. (2047 Las Colinas Ave.)
Stephenson, H. H., Y. M. C. A., Vancouver, B. C., Canada. (Brantford, Ont., Canada.)

STUDENT CHANGES*

Flessa, Edward H., Ackley, Iowa. (2522 Chamberlain, Ames, Iowa.)
Hotchkiss, Ceryl A., 1010 14th St., N. W., Canton, Ohio. (Route 2, Orient, Ohio.)

PITTSBURGH SECTION

The Pittsburgh Section will hold their first meeting of the season on Tuesday evening, Oct. 8, at the Bureau of Mines, 4900 Forbes St., Pittsburgh. Dr. T. S. Curtis of the Vitrefrax Corporation, Los Angeles, will speak on "Crystals in Ceramic Bodies." A feature of the meeting will be the première showing of a moving picture film prepared by Dr. Curtis depicting the fusion of crystalline and amorphous bodies. There will also be microphotographs in natural color, a field in which Dr. Curtis has done important research work.

OBITUARIES

George A. Parry

George A. Parry, president of the Parry Brick Company, Boston, probably the best known brickmaker in all New England, died at his home in Cambridge, July 30, after an illness which extended over the last two years.

Mr. Parry was 70 years old and had spent most of his business life in the brick business. Associated with him were two brothers, Richard and Robert, and his son, J. Harold Parry, treasurer of the company and manager of the supply business which was an important part of the company's activities. The company handled the output of several yards in Maine and New Hampshire.

One of the original nine organizers of the Common Brick Manufacturers Association, he was a vice-president and director of the association at the time of his death. The annual convention, last February, was the only annual meeting he had missed attending since the organization was perfected. He was an ardent association advocate and attributed much of his success to the effects of the organization in New England.

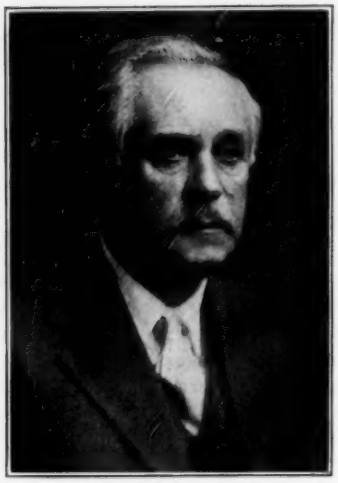
Few men have been more successful in business. Many have surpassed his accomplishments from the dollars and cents viewpoint, but rare are the men who derived more

actual enjoyment and satisfaction from personal contact and association with his fellows, who achieved warmer friendships or left a finer reputation for honesty, sincerety, and high business ideals. "The greatest thing I've gotten out of the brick business," he often declared, "is the association with and friendships of the splendid men in the industry, and that has largely been through the medium of our association." And the association will miss his kindly presence and his calm, impartial counsel.

Gustav Hottinger

Gustav Hottinger, chairman of the board of the Northwestern Terra Cotta Company and one of the most prominent supporters in advancing the ceramic arts and sciences died in Chicago, Ill., on July 27 at the age of 81 years.

Mr. Hottinger was born in Vienna, Austria in 1848 and studied modeling and sculpture at the Academy of Fine Arts. He came to America in 1869 and settled in Chicago as an employee of the Chicago Terra Cotta Works.



GUSTAV HOTTINGER

The True, Brunkhorst & Co. was organized in 1880 with Mr. Hottinger as the third partner, each associate investing $1000. The firm name was changed to True, Hottinger, & Co. in 1886, upon the death of John Brunkhorst, and a few months later was reorganized and known as the Northwestern Terra Cotta Company. His two sons, Arnold H. and Adolph F. Hottinger, both active workers in the AMERICAN CERAMIC SOCIETY are associated with this Company.

Mr. Hottinger became the sole owner of the company in 1923 and gained nation-wide attention by his gift of a $4,000,000 share in the Northwestern Terra Cotta Company to the thirty-six men who had helped him build up his great business.

The *Bulletin of the American Ceramic Society*, issue of March, 1928 carried a notice of Mr. Hottinger's contribution of $50,000 to the Association of Arts and Industries for establishing an Industrial Art School, which was an adjunct of the Art Institute of Chicago. The donation made by Mr. Hottinger completed the $260,000 quota set by the Rockefeller Foundation as the condition for an additional gift of $100,000. "The Hottinger Foundation of Architectural Modeling Founded by Gustav Hottinger, 1928" was the name of the gift as an honor to the donor's generosity and vision.

Mr. Hottinger's loss will be felt deeply, not only by his business associates and his contacts in Chicago, but by the ceramic world as a whole. The AMERICAN CERAMIC SOCIETY has lost a generous and interested friend whose place cannot be filled.

William Clippert

William Clippert, one of Detroit's leading brick manufacturers and president of the company which bears his name, died recently at his home in that city after an extended illness. He was a brother of Charles F. Clippert, president of the Clippert Brick Company, and of the late George Clippert who was also a brick manufacturer. The family has long been leader in the business in Detroit.

Horace M. Siner

Horace M. Siner, president of the H. M. and C. B. Siner Brick Company, of Philadelphia, was instantly killed in an automobile wreck at Los Angeles, California, on August 4, where he had been enjoying a vacation. The body was returned to Philadelphia for burial on August 12.

The Siner family has been actively engaged in the brick business in Philadelphia for almost a century, the business having been handed down through some four generations. With Mr. Siner, at the time of his death, was associated his brother C. B. Siner, who doubtless will continue as active head of the company.

Mr. Siner has long been keenly interested in association effort and was a director of the Common Brick Manufacturers' Association. He had served several terms as president of the Philadelphia group of this association.

Lawrence Ryan

Word has been received of the death of Lawrence Ryan, who for twenty-eight years was associated as vice-president in the interests of the Mutton Hollow Fire Brick Company and the Ryan Clay Company, Woodbridge, N. J. John F. Ryan, a brother, and secretary and treasurer of the companies has been a member of the AMERICAN CERAMIC SOCIETY since 1920.

NOTES AND NEWS

A.S.M.E. 50TH ANNIVERSARY

Washington, D. C., April 5–9, 1930

In February and April of 1880 two gatherings were held which resulted in the formation of the American Society of Mechanical Engineers. The fiftieth anniversary of these gatherings will be celebrated in 1930 with ceremonies international in scope that will record the achievements of the Society for fifty years, evaluate the influence of mechanical engineering upon the social and economic life of the country, and point the way to future development.

The preliminary meeting of the Society on Feb. 16, 1880, was held in the office of the *American Machinist*. It is fitting, therefore, that the proceedings start in New York with a visit to the present office of the *American Machinist* where appropriate ceremonies will be held. The organization meeting was held on April 7, 1880, in the auditorium of Stevens Institute of Technology at Hoboken and on the second day of the celebration in 1930 the scene of this first meeting will be visited. Stevens Institute is preparing an elaborate pageant which will depict the early life of the Society. The final three days of the celebration will be held in Washington, D. C., with an interesting program of stimulating speakers from many other nations.

Invitations have been issued to the engineering societies and engineering schools throughout the world to send delegates to this event.

CALENDAR OF CONVENTIONS

Organization	Date	Place
American Assn. for the Advancement of Science	Dec. 27–Jan. 2, 1930	Des Moines, Iowa
AMERICAN CERAMIC SOCIETY	February 16–22, 1930	Toronto, Canada
American Chemical Society	Week of April 7, 1930	Atlanta, Ga.
American Electrochemical Society	May 29–31, 1930	St. Louis, Mo.

Organization	Date	Place
American Foundrymen's Assn.	May 12–17, 1930	Cleveland, Ohio
American Gas Association	October 14–18	Atlantic City, N. J.
American Institute of Chemical Engineers	Dec. 2–4	Asheville, N. C.
American Institute of Mining and Metallurgical Engineers	February 17–20, 1930	New York, N. Y.
American Society of Mechanical Engineers	December 2–6	New York, N. Y.
Assn. of Scientific Apparatus Makers of U. S.	May, 1930	Atlantic City, N. J.
Common Brick Manufacturers Assn. of America	February 3–8, 1930	Memphis, Tenn.
International Heating and Ventilating Exposition	January 27–31, 1930	Philadelphia, Pa.
Manufacturing Chemists' Assn. of the U. S.	May, 1930	New York, N. Y.
National Academy of Sciences	April 28–30, 1930	Washington, D. C.
National Assn. of Manufacturers	October 14–16	New York, N. Y.
National Assn. of Manufacturers of Heating and Cooking Appliances	May, 1930	New York, N. Y.
National Exposition of Power and Mechanical Engineering (Eighth)	December 2–7	New York, N. Y.
National Glass Distributors Assn.	December 3–5	Pittsburgh, Pa.
National Paving Brick Manufacturers Assn.	December 4–7	Chicago, Ill.
New Jersey Clay Workers Assn.	December, 1929	New Brunswick, N. J.
Sand-Lime Brick Assn.	February 4–6, 1930	New York, N. Y.
Structural Clay Tile Assn.	February 5–7, 1930	Chicago, Ill.
Taylor Society	December 4–6	New York, N. Y.
Tile and Mantle Contractors' Assn.	April 8–12, 1930	New Orleans, La.
World Engineering Congress	November 29	Tokio, Japan

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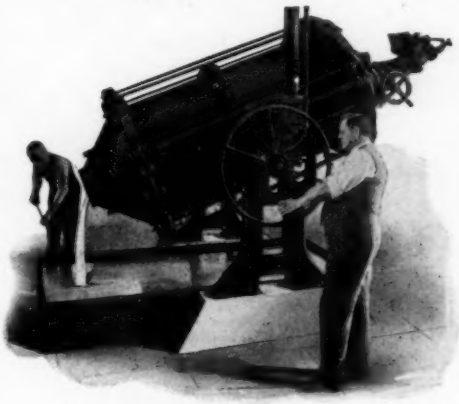

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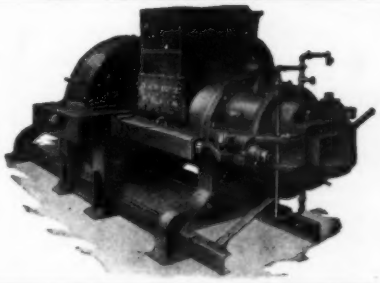

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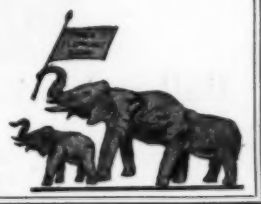

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WANTED Man experienced on artificial abrasives, either technically trained or equivalent. Should have thorough knowledge of inspection and production of grain and also ceramic bonding. Give full details of education, past experience, salary expected and when available. Address Box 73-C, American Ceramic Society, 2525 N. High St., Columbus, Ohio.

CERAMIC CHEMIST WANTED for development work by an established manufacturer. One experienced in the analysis of ceramic colors and raw materials who is capable of developing analytical methods and interpreting the results secured. Address Box 77-C, American Ceramic Society, 2525 N. High St., Columbus, Ohio.

POSITION WANTED BY CERAMIC ENGINEER with six years' experience in whiteware manufacture and research. Prefer plant work. Age 30. Married. Address Box 78-C, American Ceramic Society, 2525 N. High St., Columbus, Ohio.

The Cost of Classified Advertising Is 35 Words for $1.00 and 5c for Each Word Additional

We Have Been Producing High Grade Products for 64 Years

FELDSPAR

Regardless of the geographic location of your plant, we can supply your FELDSPAR needs from a modern operation near you. Consider the following with its possibilities for rapid and low cost delivery of highest quality FELDSPARS—

YANKEE BRANDS
Maine, New Hampshire and Connecticut FELDSPARS, ground in Maine, New Jersey and Ohio.

CANADIAN BRANDS
Highest quality Canadian FELDSPARS, ground at Rochester, New York.

DIXIE BRANDS
Southern FELDSPARS, prepared at Spruce Pine, N. C., Erwin, Tenn., Trenton, N. J., and East Liverpool, Ohio.

BEDFORD BRANDS
Pure Potash and Soda FELDSPARS, mined and ground at Bedford, N. Y.

KEYSTONE BRANDS
South Dakota Potash FELDSPARS, ground at our new mill, Keystone, S. D.

You furnish the specifications; we supply the FELDSPAR

Consolidated Feldspar Corporation

Erwin Feldspar Company, Inc.

Golding Sons Company

Trenton, N. J.

"A Combination for Trade Service"

Do YOU want more business?

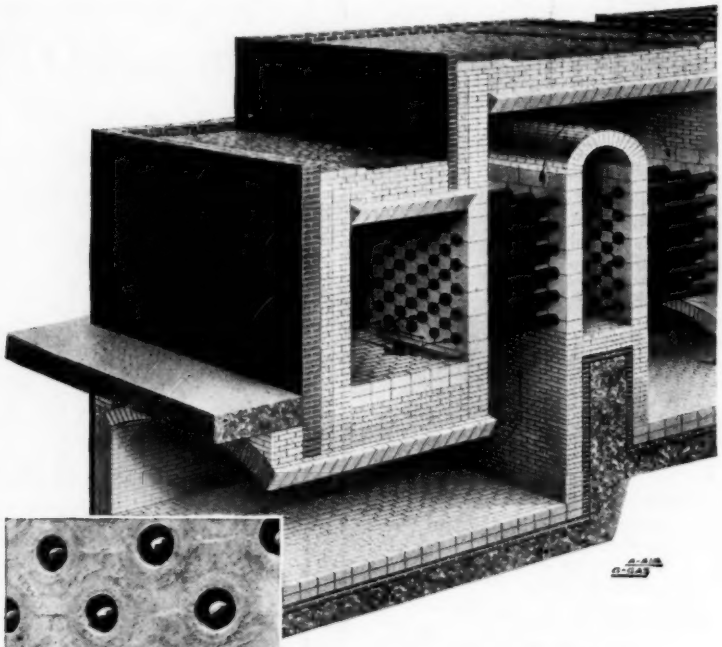
YOUR advertisement in the JOURNAL of the AMERICAN CERAMIC SOCIETY

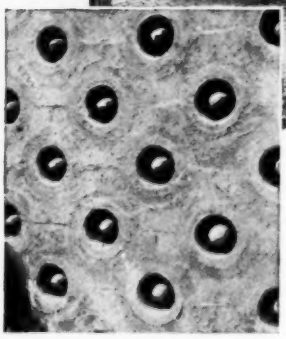
is addressed to those who decide what is to be purchased!

For rates and further information, write to

American Ceramic Society
2525 N. High St.
Columbus, Ohio

Another Successful Installation





NOT a crack in the terminal wall—every Carbofrax Tube straight and true. Not a leak—after three years' service.

CARBORUNDUM RECUPERATORS

DESIGNED—INSTALLED BY OUR ENGINEERS

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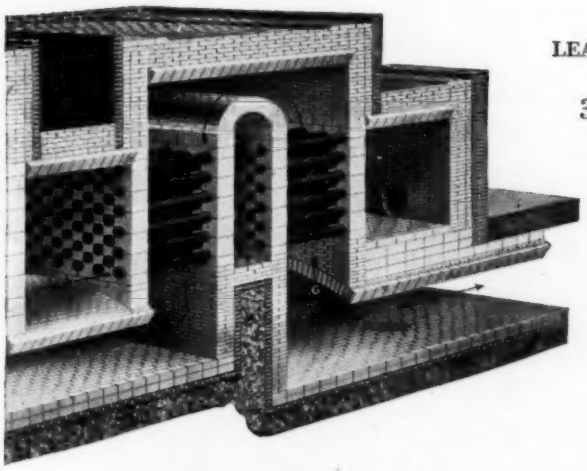
Write for Descriptive Bulletins

The CARBORUNDUM
REG. U. S. PAT. OFF.

(When writing to advertisers, please mention the JOURNAL)

of the Carborundum Recuperator

REG. U. S. PAT. OFF.



NOT A
LEAK OR CRACK
AFTER
3 YEARS'
SERVICE

A Carborundum Brand Recuperator as illustrated was installed at the Hanley Ceramic Company's Plant at Summerville, Pa. After three years' service not a leak—not a crack had developed in the tubes or terminal walls.

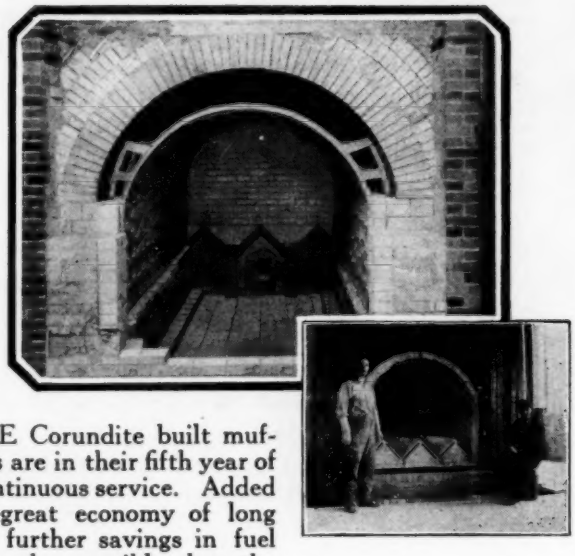
¶Every tube of Carbofrax—the Carborundum Brand Silicon Carbide Refractory—was still straight and true.

¶One of the chief reasons for the success of the Carborundum Recuperator lies in the fact that banks of Carbofrax tubes comprise the heat transfer media—Carbofrax tubes with their high thermal conductivity insure efficient heat recovery. Long life and continuous operation are obtained because of the great mechanical strength and durability of the tubes.

(Carborundum is the Registered Trade Mark of The Carborundum Company for its products)

Company, Perth Amboy, N. J.

There's YEARS of service in CORUNDITE Manion "V" Bottom Muffles



SOME Corundite built muffles are in their fifth year of continuous service. Added to this great economy of long life are further savings in fuel costs made possible by the Manion "V" bottom design. This design permits of higher heat conductivity, affords greater heat radiating surface and in general is an improvement over the box type muffle.

We'll be glad to supply you with names of users of Corundite built Manion "V" Bottom Muffles. Just write.

This Manion "V" Bottom Muffle is built of Corundite materials only. Larger photograph shows details of construction and below is the completed job.

Ask for prices and bulletin.

CORUNDITE

Refractories, Incorporated

Massillon, Ohio **Since 1882**

McDANEL IMPERVITE—THE *SUPERTITE* PYROMETER PROTECTION TUBE

STRENGTH

Like the Old Wall of China, THIS tube is resistant to the strongest forces of destruction!

McDANEL IMPERVITE

The *SUPERTITE* Pyrometer Protection Tube

It takes more than the strength of an ordinary pyrometer protection tube to combat the destruction to which thermocouples are subjected... and the new McDanel Impervite SUPERTITE is more than an ordinary tube.

McDanel Impervite SUPERTITE is especially designed for severe operating conditions. High-fired, it can be used with absolute safety in temperatures up to 2900° F. Gas tight in *all* temperatures...chemically inert...resistant to the shock of rapid changes...will not crack, sag or bend.

Because of its greater strength, McDanel Impervite SUPERTITE is far longer-lived...OUTLASTS all other tubes now obtainable.

We are the exclusive distributors of this remarkable tube. Tell us the length and inside diameter of the tubes you require and let us quote prices. We can make immediate deliveries from stock. All tubes unconditionally guaranteed!

Bulletin mailed on request. Write Dept. B

CHAS. ENGELHARD INC.

233 N.J.R.R. AVE. NEWARK N. J.

Recording and indicating instruments automatic temperature and gas control, pyrometers, gas analyzers, thermo-couples, thermometers.

STANDARD FOR 30 YEARS

Chicago, New York, Boston, Pittsburgh, Cleveland, St. Louis, Montreal, Ottawa, Toronto, R. E. Chase & Co., Tacoma, Wash., Jensen Instrument Co., Los Angeles, Cal.

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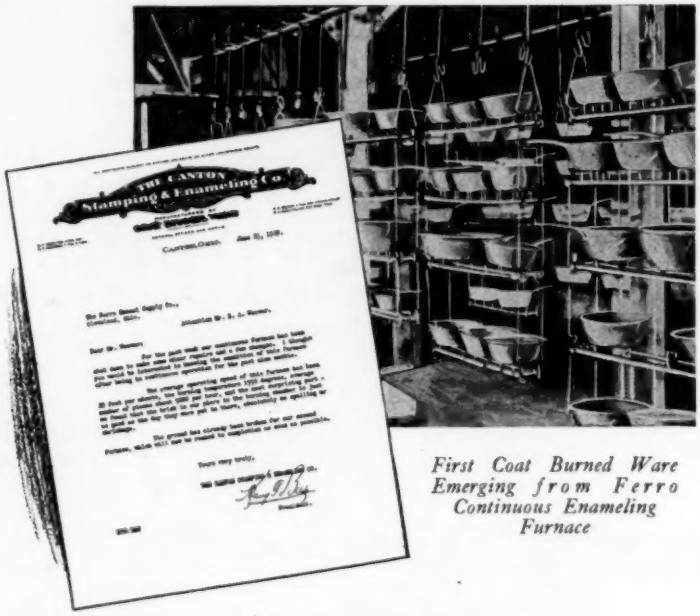

First Coat Burned Ware Emerging from Ferro Continuous Enameling Furnace

9 MONTH'S SERVICE— STILL GOOD AS NEW!

WHEN the Ferro Single End type Continuous Furnace installed at the Canton Stamping & Enameling Company was recently closed for repairs, it showed that after nine month's of continuous operation, furnace interior was as good as new!

Average production had been 5000 pieces of enamelware per hour . . . . During this time over eighty dollars a day had been saved in labor alone as compared with box type furnaces previously used.

The Ferro Single End Continuous Enameling Furnace is built to endure—and to show unusual savings for the owner. That's why it will pay you, when investigating continuous furnaces, to write us for full details.

THE FERRO ENAMEL SUPPLY CO.

CLEVELAND, OHIO

Established 1869

B. F. DRAKENFELD & CO.

Incorporated

For Best and Certain Results Use Only

HIGHLY STANDARDIZED

METALLIC OXIDES CHEMICALS

BLACK OXIDE COBALT

COBALT SULPHATE

Especially Prepared for the Silicate Industries

45–7 Park Place New York

East Liverpool Ohio Chicago Illinois

Works: Washington Penna.

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Humidity Dryer for Insulators

"HURRICANE" DRYERS

for Quantity Production

With "Hurricane" Dryers properly suited to your plant, **drying, like all efficient production, proceeds according to a definite time schedule. The work flows through the dryer at a uniform rate, without loss of time, energy, or space.**

Aside from "HURRICANE" dryers of the Continuous Conveyor Type there are "HURRICANE" Truck and Tunnel Truck Dryers, Stove Rooms and Mangles for all types of ceramic and enamel ware.

THE PHILADELPHIA DRYING MACHINERY CO.
3351 Stokley Street, Philadelphia, Pa.
New England Office: 53 State St., Boston, Mass. 167-A

Since 1848
Importers of

ENGLISH CHINA CLAYS
ENGLISH BALL CLAYS
CORNWALL STONE
TALC (STEATITE)

Dependable Qualities of Ceramic Materials for all Branches of the Industry

HAMMILL & GILLESPIE, INC.
225 Broadway
New York

Why

LAKE COUNTY CLAY
for
ENAMELING?

Because

It is proving highly satisfactory in several Enameling plants—it is thoroughly washed and disintegrated. It burns very white and holds the enamel in suspension.

LAKE COUNTY CLAY CO.
General Offices:
METUCHEN, N. J.

Proper Processing of Ceramic Wares demands Drying Control

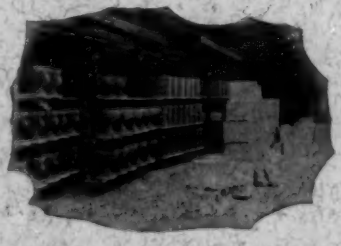
Proctor Dryers give the control of correct drying that overcomes costly defects.

Proctor Dryers have made the drying of ceramic products as definite a mechanical process as the operation of a mechanical stoker in the boiler room.

In the design of these machines, the elements of drying...air, heat and moisture...are combined and controlled in a positive mechanical manner.

This achieves a close control of conditions to suit any kind of ware in each drying stage...so as to deliver the ware in uniform condition, dried to the desired degree with dependable regularity.

Because they use Proctor Dryers and control their drying, manufacturers in all branches of ceramic production have reduced their losses in drying to the point of almost total elimination, saving on a tremendous scale in many cases. In addition, Proctor Dryers effect savings in time, labor, space, steam, which go to make their installation decidedly profitable for any ceramic manufacturer.



PROCTOR & SCHWARTZ, INC.

PHILADELPHIA

"And They Keep On Buying"

Every month we are gaining new customers for our tin oxide—and they keep on buying. This proves again that *"A good article sold at a fair price will find an ever-widening market."*

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